

Beehive in Muir Is Stage for Interpretive Dance Performance

by Isaac Pearlman

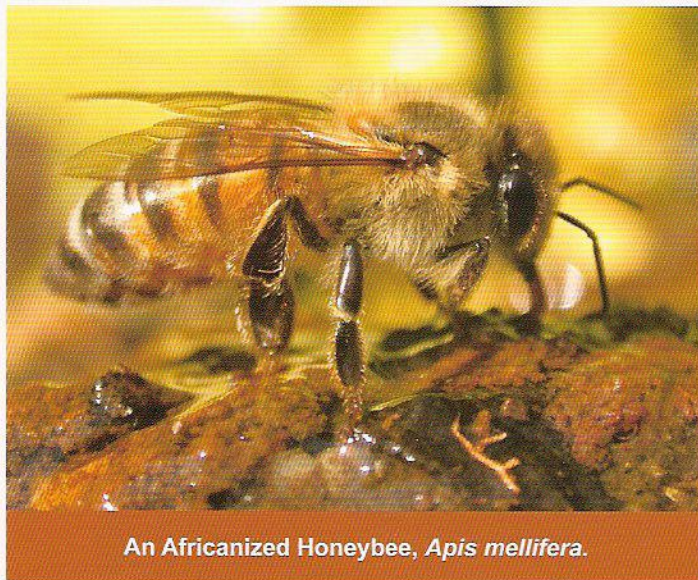
Inside a corner laboratory of the first floor of the Muir Biology Building an unadorned rectangular wooden box the size of a windowpane sits on top of a Lazy Susan. The simple frame looks out of place amid the books and high-tech equipment, but when the door covering it is opened, a complex, honeycombed world formed from labyrinths of hexagonal cells is revealed. Honeybees swarm in and out of the fully functional beehive, laboring over chambers filled with larvae and food. The nest connects to tubes leading out the side of the building, allowing these particular experimental subjects to leave whenever they wish.

James Nieh, an assistant professor of biology, has been studying bees for years and is currently trying to crack the code for how bees communicate. His method? Close study and experimentation with the two beehives he installed in his laboratory on the Muir College campus. "What we are trying to do with these colonies is study communication," he says. "There are many issues we don't understand: how bees communicate motivation, for example. We see that when a bee is excited, she comes back to the nest with a different behavior, but we don't understand exactly how she communicates this excitement to other bees."

Specifically, Nieh is interested in studying the evolution of animal language in bees. His research encompasses two types of bees that exhibit different forms of communication: honeybees, which use an extremely sophisticated form of communication known as the "waggle dance" that allows foragers to communicate location and distance of food sources to bees inside the nest, and bumblebees, which use a simpler method of communication that cannot indicate food location.

His studies are the reason bees can be seen flying daily in and out of the Muir Biology Building. However, even though the hives have only taken up residence in Muir a short period of time, they are not the first controlled beehives on campus. "The current colony has only been here a couple of months, the old ones died out," explains Nieh, referring to his previous attempts to maintain a beehive for experimentation which failed for varied reasons including disease, changes in climate due to seasonality and even invasive Argentine ants.

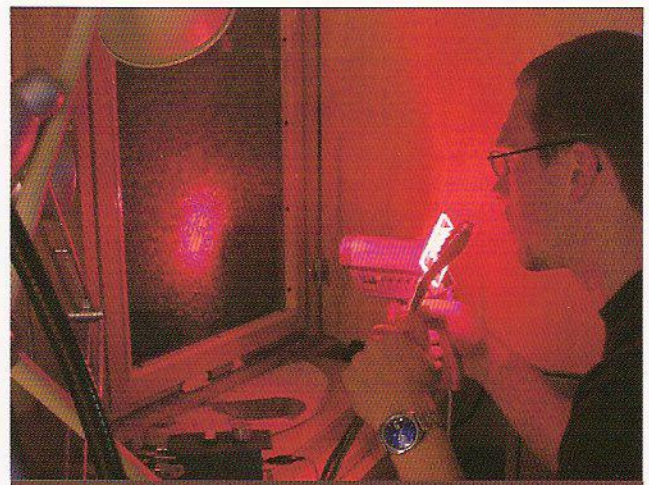
The two current bumblebee hives are contained in boxes built by graduate students. Inside a darkened side room in Nieh's laboratory sits the bumblebee colony, the nest the size of a credit card and just beginning to be built by the newly transported bees. Inside the lighted box, nickel-sized black bumblebees take food from small dishes laid out in the box and head back to the queen. Hovering in the background, graduate students carefully record data, while a camera keeps watch over the nest and shows the picture on a monitor in the back of the room. In the other room, the honeybee hive is much bigger, and the Lazy Susan allows researchers to examine it from different angles. Nieh opens the door to the wooden box and



An Africanized Honeybee, *Apis mellifera*.

reveals a mass of bees crawling over each other, and in and out of hollow passages, all trapped under a pane of glass. "One way foragers may express motivation is with body temperature," says Nieh. "In a completely dark nest, if others can feel that the forager is really hot, they may know that resource is good."

Nieh points what looks like a radar gun at a thick cluster of bees covering a fist-sized portion of the nest and looks at the monitor on the back of the gun. The dark screen of the thermal camera shows a yellow-orange outline of a single bee, standing out in contrast to the darker, cooler outlines of her nestmates. This bee, explains Nieh, may be trying to communicate. Nieh can watch this bee dance inside the nest and map



T. J. Hiebel Studying the Honeybee Waggle Dance

out where in the surrounding area the bee is going to collect food as she is trying to convey this information to her nestmates. Amazingly enough, as Nieh and his team have mapped out this information, they have found that most of the bees are foraging in areas coinciding with areas of natural vegetation and away from artificial gardens, yielding a natural map based solely on bee communication with its nestmates of the remaining native vegetation in the area.

Why study how bees community and why they have developed the method of communication that they have? According to Nieh, bees can use sound, odor and vision to communicate in addition to thermal and tactile sense. This complexity is what sets bees apart from most species. They have the ability to use what is known as "functionally referential communication," or the capability to use abstract representations to communicate information. With his two hives, Nieh is attempting to discover the evolutionary reasons why bees have developed such a complex form of communication. "There must be some special advantage that such communication gives bees," says Nieh. "Otherwise, what is it good for?"

The reason there must be a particular value for its evolution is the fact that functionally referential communication is difficult to evolve and requires cognitive complexity, a good memory and a certain level of navigational ability. Nieh hypothesizes that one reason for

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products, and possibilities from the agricultural side would be the discovery of novel herbicides or insecticides."

Short and Simon's vision has already become a reality. In 2004, Diversa introduced three products based on these novel microbial genes. One was an enzyme called Luminase for a pulp and paper process that is capable of replacing over one quarter of all the bleaching chemicals in the world, which is primarily comprised of chlorine dioxide. According to Short, "We are testing Luminase right now in paper mills, and we are enthusiastic that it is going to be a powerful asset to both the chemical industry and the pulp and paper industry. By using these biologically based enzymes, manufacturers can make better products while reducing the regulatory pressure they have with the dioxin that is generated from the chlorine dioxide. Ultimately, use of the Luminase enzyme will allow pulp and paper manufacturers to improve the cost and quality of pulp processing."

The Luminase enzyme was originally discovered from a soil sample from the Geyser Valley in the Kamchatka region of Russia. Short explains the process, "It was a terrestrial alkaline thermal vent that was boiling voraciously. We were able to isolate the DNA from a water sample taken at the mouth of the vent, and we screened for an enzyme that could open up wood fibers. Opening up wood fibers reduces the amount of chemical needed to penetrate those fibers in the bleaching

process, thereby reducing the amount of chemical, resulting in a much more cost effective process. Now, we have the capability of taking the gene from those microscopic organisms and producing multi-ton quantities of the enzyme encoded by that gene. And we accomplished commercialization of this product less than 30 months after sampling in Russia!"

Diversa's business philosophy is also on the cutting edge. It is committed to sharing its success with the organism's country of origin. "From its beginning, Diversa has been committed to giving back to the countries from which we were taking samples, even though in some cases the sample was only the size of a tablespoon," notes Short. "But we are really modeling our program after the convention of biological diversity, which says that the biological diversity within each country is a sovereign right of that country. One of the early challenges for us was determining what kind of sharing was appropriate. Our strategy was to not only pay for their expertise and samples but to also train their scientists, that is, we do capacity building. We bring those scientists to Diversa and train them in molecular biology and microbiology techniques, allowing them to further their own research."

During a time when the biotechnology industry is being heavily criticized by environmentalists, Diversa's environmental consciousness has resulted in the company's being invited to several environmental conferences around the

world. Short emphasizes the commitment, "We are all environmentalists in the company. So working with environmental organizations is easy. For example, we work with Yellowstone National Park, which includes some of the country's strongest environmentalists and advocates. It's a win-win situation."

In June 2004, Diversa was named one of the ten best places to work among small companies in the life sciences industry, according to The Scientist's "2004 Best Places to Work in Industry" survey. Short describes the type of scientist Diversa looks for, "We are definitely looking for people who can speak multiple scientific languages. Having a good working knowledge of chemistry, biochemistry, biology, microbiology, mathematics, and statistics makes these people very powerful and rare. I think San Diego has done a decent job of creating institutes and environments that foster that kind of translational knowledge. We estimate that we are moving up from a few million dollars in sales from these meta-genomic products right now, to more than a hundred million dollars worth of sales within three years from these meta-genomics products. We are going to need not only people with basic research knowledge but also more sophisticated people in the areas of manufacturing, expression, and purification knowledge."

When asked how meta-genomics will influence our day-to-day lives, Short says, "I believe products that are developed from our research will contribute to many fields, including pharmaceuticals, all parts of the chemical industry, agriculture, and even can start new industries associated with novel materials. That is why I am glad to see UCSD moving ahead in this field, because it is going to influence every business, every institute and every department. This definitely has to be a multidisciplinary effort. It has to include everybody."

On a practical level, Short describes a possible solution to a common problem. "Bringing it back to an everyday issue, communities of organisms can generate biofilms that can do everything from clogging water pipes to causing infections. If we can understand how to keep those systems in balance with very small molecular controls instead of just bombing everything with chemicals, perhaps we won't have to keep switching pipes and maybe we could cure people faster. There are layers and layers of things that can be addressed if we can start to understand the intricacies of microbial communities with these new technologies."

Diversa may very well convert the well-known 20th century slogan, "Better living through chemistry" to "Better living through biology." Actually, not only better living but also a better environment.

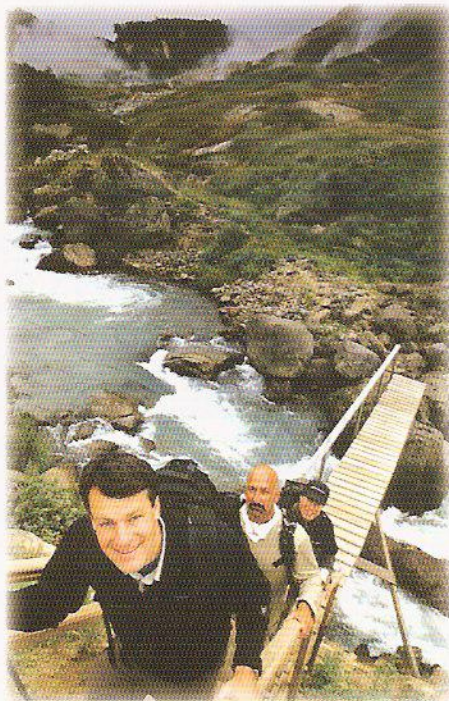
For more information about Diversa, visit: www.diversa.com. Photo credits: Frans Lanting, www.lanting.com.

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the evolution of referential communication is that it allows bees to escape from "espionage" by other bees. Some bee species specialize in spying out the food sources discovered by other species, using the odor trails that some bees deposit to guide nestmates to good food. Such odor trails have a higher cost in that if intercepted by a predator, a whole colony could be killed. It may be better to hide their communication inside the nest.

Humans are one of the few other species that can use this form of communication, and according to Nieh, the possible parallels in the development of language in both species are fascinating. "I think it's interesting to speculate on the role that espionage and eavesdropping has played in complex language. For example, in human society, many advances in written language have involved cryptography, showing the need to conceal information and to keep it secret." So the next time you see a bee buzzing around Muir College, watch out. That particular bee might just be heading back to communicate to its nestmates the location of a rich food source and to convey to Nieh another piece of the complex puzzle that is bee communication.

For more information about Dr. Nieh's research, visit: www.biology.ucsd.edu/faculty/nieh.html.



Jay M. Short, Ph.D., president and CEO of Diversa, Eric Mathur, vice president, scientific affairs, and Leif Christoffersen, manager, biodiversity, cross the Geysernaya River in Geyser Valley in Kamchatka after collecting samples from the Velikan (Giant) Geyser, which shoots water 90 to 120 feet into the air for about one minute every five hours.