Bill Hansson

He is the master of scents.

Bill Hansson studies insects’ sense of smell. He wants to find out which odor molecules attract specific species, and how the information is processed. And, of course, the Director at the Max Planck Institute for Chemical Ecology in Jena is also interested in what effect this has on evolution and behavior.

It’s a cloudy November day. The surrounding institute buildings on Jena’s Beutenberg campus are brightly lit. A warm light emanates from the neighboring greenhouse. Bill Hansson’s office in the department of Evolutionary Neuroethology at the Max Planck Institute for Chemical Ecology, whose Director he became last September, is a spacious room decorated with modern, unpretentious furnishings. A look at his department’s labs – still in the process of being refurbished – already gives the visitor a presentiment of the state-of-the-art research that will take place here.

So it doesn’t quite seem to fit that Hansson’s eyes shine with such enthusiasm when he talks about his little house with its own forest in the southern Swedish region of Småland, conjuring up images of clear streams, wild strawberries and walking barefoot. The scientist does, in fact, live a completely different life when he’s there, spending his time hunting or managing his forest. “Just last week, I felled three trees for our new house in Jena,” he explains. “After all, I’m bringing my whole family from Sweden to Germany, and we’re going to need our own sauna,” he says with a wink. The trees in the family’s own forest provide just the right kind of wood.

Cutting Down Trees for a Change

“I like the simplicity of working with my hands, and I look for physical challenges – perhaps partly to balance out my work as a researcher,” says Hansson, explaining the seemingly different life he leads back home. “That’s why I go running regularly when I’m here in Jena.” And the scientist loves variety. “One day I might be cutting down a tree, and the next I’ll be back to my research. Or another time, I might be hunting in our forest, only to spend the next week in a hotel attending a conference – it’s great.”

For Hansson and his family, the country living in their Swedish homeland and working in their own forest must surely be the ideal way of getting away from it all. Yet the direct connection with his research work can hardly be overlooked. Just last summer, the forest in Småland became infested with bark beetles. “That was really bad,” Hansson recalls. But his colleagues from the Swedish University of Agricultural Sciences in Alnarp jumped at the opportunity to carry out a field study, setting up traps in the forest – pheromone traps, naturally.

“In a case like this, you can really see how important the sense of smell and odor attractants are – for biology, as well as for the economy,” says Bill Hansson with a smile, his eyes shining with enthusiasm again. “It’s absolutely fascinating.” And pest control is not even his specialty. It’s more the subject of his Ph.D. supervisior, the late Jan Löfquist, who, since the 1970s, studied how pheromones – or sexual attractants – could be used in place of pesticides.

Hansson did his Ph.D. under Löfquist at the University of Lund in Skåne, Sweden’s southernmost province – naturally on the subject of attractants. As a young doctoral candidate, the Max Planck Director studied how insects use pheromones and the accompanying receptors to locate sexual partners within their own species.

In a certain way, this seemed to set the course for the future of his career in research. Yet he says it was somewhat of a coincidence that he happened upon Löfquist and the pheromones. “Like most students, I was looking for an interesting project, and then just started doing what I found,” says Hansson. He continues: “It was only much later that I really realized that this was my thing, that the olfactory sense of insects, or their sense of smell, and the role it plays in their behavior and their evolution, was exactly what I wanted to research.”

Initially, it appeared that the Swede would take a different path after completing his Ph.D.: as a post doc at the Arizona Research Laboratories of the University of Arizona, he turned to neurobiology, or to be more precise, to insect brains. In fact, this was not much of a departure from his original path. After all, the sense of smell doesn’t end with the receptors. Odors, or the reactions they trigger, must also reach the brain, where they are processed and produce a certain behavior.

This is exactly what Hansson finds so exciting about his job: uncovering the big link, the interaction between odors and receptors, the processing of stimuli in the brain and the behavior that results. Or, as he
Catching a coconut crab (Birgus latro) is a tricky business – its claws can crack a coconut.

puts it, “We study the whole story here, from the moment the sweet smell of the cake reaches the nose to the moment of finally succumbing and taking a big bite.” Except that it is with insects, and not people. Of course, Hansson also wants to know how all of this affects evolution and the ecological niches the insects specialize in – and vice-versa.

A Pound of Sugar in the Baltic Sea

Studying the sense of smell in insects is an obvious choice. With their antennae, the feelers with which they search out odors, insects are around 100 million times more sensitive than human beings in this respect. “The power of a moth’s olfactory sense is like pouring a pound of sugar into the Baltic Sea – and then being able to taste it,” explains the scientist.

According to Hansson, there’s still a lot of work to be done in this area. American researchers Richard Axel and Linda Buck won a Nobel Prize for their work on olfactory system research in mice. Nevertheless, not much is really known about how the whole thing works, says Hansson. He cites an example: “We have almost 350 different odor receptors in our noses, yet we can detect perhaps 100,000 different smells. You have to ask yourself how the brain manages it, how our nerve pathways modulate the information so that the right reaction is produced in the end.” And which odors actually cause us to act in a particular way – like really wanting to eat certain things, but leaving spoiled food untouched.

Just which molecules “hit the spot” is one of the questions the researcher is working on. Bill Hansson always starts with natural odors, which he separates in the gas chromatograph before offering the individual components to his insects, such as the popular lab fly, Drosophila melanogaster, and examining which ones they react to.

About his method, the scientist says, “You could, of course, take individual, chemically synthesized odor molecules, but the results you get under such artificial laboratory conditions usually have little relationship to reality.” For him, it is especially important to start on the basis of natural conditions. Especially in the case of Drosophila, Hansson complains that many researchers have long forgotten that the insect is more than just a lab fly, Drosophila melanogaster, and examining which ones they react to.

Strange Mixture of Pineapple and Gorgonzola

He has also discovered why some Drosophila species prefer a completely different range of foods than those consumed by the famous lab insect. Drosophila sechellia is a cousin that, as its name suggests, is native to the Seychelles, the only place where it can be found. This insect focuses on the fruit of the noni tree, which has a scent of pineapple and Gorgonzola. The tree serves the insect both as a food source and as the only host for its eggs. Surprisingly, though, the fruits of this tree are poisonous to other insects. This might be the key to the specialization of D. sechellia: “The different receptor has an especially strong reaction to methyl hexanoate, a substance in the noni odor mixture that the insect obviously finds extraordinarily attractive.”

A cell culture model is helpful in the search for these kinds of anomalies: human kidney cells in which scientists induce the expression of the different olfactory receptors. In the culture dish, researchers can check which receptors pick up which odors, recognize them and transmit the information to the brain.

The cell system is also a way of characterizing these docking points for odor molecules in more detail and studying how they work. And this is where a big surprise may be lurking. As Dieter Wicher, a member of Hansson’s team and head of the neurophysiology research group, explains, “The receptors of an insect are built differently than those of human beings and vertebrates in general.” No one knows quite how the detectors of these air-borne masters of odor work, but it is very possible that the scientists from the neuroethology department may be hot on the heels of a completely new category of odor receptors.

However, a man who, like Hansson, seeks out variety constantly finds himself drawn out of the lab and back to nature. Sometimes even to the remotest corners of the Earth, like Christmas Island in the Indian Ocean. There, he and his team set out on the trail of a particularly strange creature. The island, like others in the Indian and Pacific Oceans, is home to the coconut crab, also known as the robber crab (Birgus latro). The enormous crabs of this land-living species weigh up to 4 kilos and can grow to more than 50 centimeters long. They feed on carrion and fruits and can climb trees and even open coconuts – the same name.

In the course of evolution, these creatures have adapted extremely well to life on dry land. For instance, they use a special organ called a bra-chialostegal lung to breathe. This organ represents a developmental stage between gills and lungs, allowing the crabs to absorb oxygen from the air. In water, the crabs would suffocate if only their larva can live in that habitat.

Smelling with Its Feelers

“What a creature as well adapted as this one is, we naturally wondered what its olfactory organs were like,” says Bill Hansson. If the crabs are no longer capable of picking up odor molecules diffused in water, they must have found another way to

A section through the antennal lobe of the European corn borer looks like a piece of abstract art. The red background is antisynapsin staining in which a single nerve cell can be seen as a tiny green spot at the top of the picture.
smell. The sense of smell is clearly significant for the arthropods, since one of their food sources is carrion, which is very strong smelling. As it turns out, the coconut crab does, in fact, smell with its long feelers – in the very same way that insects do. The scientists came to this conclusion upon examining the reaction of the nerve cells behind the olfactory receptors. The kinetic profile of the reaction – again measured using microelectrodes – was virtually identical for Drosophila and the giant crabs.

In order to prove that not only the receptors in the coconut crab’s feelers respond to odor molecules, but that the brain actually receives “smell” information, the researchers put out some bait: they prepared odor samples diffused in paraffin oil, which they hung out in net bags 50 centimeters above the ground. The crabs did actually pick up the odor with their feelers and moved purposefully toward the odor-emitting bags. Control bags containing nothing more than paraffin oil solicited absolutely no response.

“It’s really amazing,” says the Max Planck scientist, “that a creature originally at home in the water has adapted so well to living on land that it has modified its olfactory organs to resemble those of other animals.” However, the coconut crab still puzzles the experts in other ways. “For example, we still have no idea how the odor molecules reach the receptors in the first place,” says Hansson. After all, the giant crab, like other crustaceans, has an exoskeleton surrounding its body like a suit of armor. The scientists have not yet been able to make out the existence of any pores through which the odor molecules could penetrate the shell.

Then Bill Hansson relates another experience that has stayed with him to this day: “When we were on the island, we could find only male crabs in the wooded areas; there wasn’t a single female there.” That was strange, and even the locals couldn’t explain it. “Only much later did we notice that there were caves along the whole of the seafloor – and there, up the walls and on the ceiling, sat the females, their undersides covered with eggs, ready to soon lay them in the sea.”

The team had apparently reached Christmas Island right after the mating season. The male crabs stayed behind in the safety of the woods while the females set off on their solitary journey down to the sea, where the next generation of giant arthropods would spend the early part of its life. “That was absolutely fascinating,” says Hansson. “It makes you want to go right back there and study them some more, for example to learn how the crabs find their way back to each other when the next mating season comes around.”

**JENA, TOO, IS UNCOMPLICATED**

Bill Hansson lives a researcher’s life between the idyllic Swedish countryside and the tropical islands of the Indian Ocean. Does he find the move to Jena a difficult prospect? “Not at all,” he answers. Of course, it’s not easy for the children, from a language point of view. And they’re leaving all their school friends behind. But the scientist has already enrolled 10-year-old Otto and 8-year-old Agnes in a school that teaches according to the Jena Plan, a school model developed by pedagogue Peter Petersen at the University of Jena in the 1930s. Since the method adopts a child-based approach, Hansson hopes that it won’t be too hard for his kids to make the transition from the Swedish schooling system. He is sure that they will all soon start to feel right at home in Jena, as “it’s uncomplicated, just like Lund, where we used to live.”

**SCIENTIFIC WITNESS OF THE MATING GAME**

For Hansson, joining the Max Planck Institute for Chemical Ecology is “just fantastic.” He sees it as a great challenge to be able to build up a new department from scratch. There’s also the infrastructure and the opportunity for cooperation. And there’s something else, too, he admits with an impish smile: “It just feels good to know that my work is recognized, that people take notice of it, and that they want me here in this unique environment.”

Hansson is looking forward to his work in Jena, and the city has already given him a special welcome of sorts – an experience that makes his scientist’s heart race: upon leaving the institute one evening in late summer, he came across a female rusty tussock moth surrounded by eggs. Bill Hansson picked the insect up on a piece of paper – the flightless female of this moth species emerges from her cocoon and then waits right next to it for a male to come along and mate with her – and carried it carefully to the terrace, where he found good lighting to take pictures.

“I watched as the moth moved her abdomen, and three males that located her by their enormous antennae came up out of nowhere, ready to mate with her. That kind of thing is just fascinating, no matter how many times you see it,” says the scientist. And there it is again, that look of sheer enthusiasm in his eyes.