Suzanne Eaton

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Think of a fruit fly embryo as an automobile coming down the assembly line, its exterior bolted together from 19 pieces called imaginal discs. Only a fly is not a car. Its embryonic sheet metal is alive and self-assembling. How an imaginal disc engineers itself into becoming a wing or a leg is one of the hottest topics in *Drosophila* embryology. So when Suzanne Eaton first described a novel mechanism for delivering powerful shape-ordering proteins called morphogens across a developing imaginal disc, it attracted attention and controversy. An American at the Max Planck Institute for Molecular Cell Biology and Genetics in Dresden, Germany, Eaton reported that morphogen proteins like Hedgehog and Wingless were being ferried from cell to cell on lipoprotein particles.

"The jury is still out on this," says Tom Kornberg of Eaton's lipid-linked morphogen model. Yet the model reflects everything that Kornberg admires most about Suzanne Eaton, who was a postdoc in his University of California, San Francisco lab from 1988 to 1993. "It's a very imaginative and bold idea," continues Kornberg. "Suzanne is also taking full advantage of her unique background in signaling and developmental biology, plus her expertise in membrane trafficking and transport." Only Kornberg doesn't buy it yet. Other labs, including Kornberg's, are still hard at work on alternative mechanisms for morphogen distribution. None of which, says Kornberg, detracts from his appreciation of Eaton's "spectacular" skills as a researcher. "Plus anyone who's interacted with her knows what a lovely person she is," Kornberg adds.

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Lipoprotein Particles as Vehicles for Morphogens

Having the scientific imagination to advance a new model—and the experimental skills to back it up—are the hallmarks of Eaton's style, according to Marino Zerial. He's Eaton's colleague at MPI in Dresden, and nominated her for the ASCB's 2006 Women in Cell Biology (WICB) Junior Career Recognition Award. (Eaton was a co-WICB awardee with Karen Oegema of the Ludwig Institute in San Diego.) Zerial believes that the scientific jury will eventually come down on the side of Eaton's lipoprotein particles-morphogen model. That doesn't exclude other morphogen distribution mechanisms, he points out. "This [model] is, in my view, one of the most significant contributions in the field of developmental biology of the past 10 to 20 years," Zerial believes.

Eaton is also the very model of the modern major multidisciplinary researcher. Zerial explains that the MPI in Dresden was set up to erase traditional borders between cell biology, developmental biology, biochemistry, and genetics. "Suzanne has the right personality to do this. She has the right attitude for collaboration and for sharing information," he observes.

Occasionally, her collegiality can go too far, Zerial recalls with laugh. "We were in Kai's [Simons] office. It was Suzanne, me, and Marcos [González-Gaitán] going over some technical thing when suddenly Suzanne jumped from her seat and said, 'Oh, my God! My speaker!'" The visiting seminar speaker was Jean-Paul Vincent from the National Institute of Medical Research in London. Zerial remembers, "We all rushed downstairs and there was Jean-Paul waiting to be introduced. Suzanne was so embarrassed. But Jean-Paul is an old friend, and he probably knew that we were all lost in some mechanistic discussion."

The Fly Geneticist's Swiss Army Knife

For her part, Eaton believes that her work has benefited in Dresden from having the right mix of collaborators and the right toolbox in *Drosophila* genetics to pursue difficult questions: "The amazing strength of *Drosophila* is that you can just about do anything with it. You can do biochemistry. You can do cell biology

experiments." Tools developed by *Drosophila* geneticists can precisely manipulate expression patterns in a living creature. "It's not just on or off but exact control in time and in space," Eaton claims. With methods like Gal4-UAS—which has been called the "fly geneticist's Swiss Army knife"—or FLP-out cassettes (commonly called "flip-outs"), Eaton describes how, "You can block endocytosis in half the wing, then turn this thing on and look for what happens a few hours later. That's all the time it takes. *Drosophila* is that powerful a tool."

Suzanne Eaton is a native Californian, a long way from Oakland, where she was born. Her father, who taught electrical engineering at Berkeley, moved the family when she was 11 to Armonk, New York, after IBM recruited him. Eaton says she went to a great public high school—Byram Hills—and on to a great private university—Brown. As an undergraduate, Eaton was torn between a career as a biologist, a comparative literature professor, or a mathematician. A tipping point was a developmental biology course at Brown where there was no textbook. Instead the instructors handed out copies of all the seminal papers in the field. Eaton recalls, "They didn't teach us the 'facts.' They just said, 'If you have any questions, come back and ask us.' That just led to an explosion of questions. I still think that's the best way to learn."

After graduation, Eaton worked for a year as a daytime lab technician and a nighttime cocktail waitress. "Being a cocktail waitress in Providence really convinced me to go to graduate school," she declares. On her last Saturday night, there was a brawl at the pool table involving cues and a stranger in the kitchen helping himself to a large knife. "He told me he was 'Doin' a favah for a friend,'" Eaton explains in a dead-on Rhode Island accent.

Joining The Fly World

Eaton did her thesis with immunologist Kathryn Calame at the University of California, Los Angeles, working on immunoglobulin gene transcription. It was an exciting time when molecular biology was transforming immunology, Eaton recalls. "Nobody had gotten her or his hands on the molecules before."

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By the time she earned her doctorate in 1988, her interests had shifted to the larger puzzle of cell fate. Eaton looked for a lab that combined molecular and developmental biology. That led her to Tom Kornberg at UCSF and her introduction to the fly world. In the Kornberg lab, she worked on the cloning of the famous fly morphogen genes, Hedgehog and Cubitus Interruptus.

At UCSF, Eaton also met Tony Hyman, an English postdoc in Tim Mitchison's lab. "He showed me how to use the confocal microscope," she remembers. "Then I noticed he had a bicycle next to his desk. I was intensely into cycling then, so that was the start of that."

It was also the start of a relationship that would take Eaton from the Bay Area to Germany. Hyman was already considering a Group Leader position at the European Molecular Biology Laboratory (EMBL) in Heidelberg. When EMBL's Kai Simons came on a visit to UCSF, Eaton talked with him about her background in developmental biology. It meshed with Simon's interest in epithelial polarity.

"I really can't tell you how grateful I am to Kai," says Eaton, for taking her into his Heidelberg lab as a postdoc. "He taught me so much." In the Simons lab, Eaton worked on planar polarity and the emerging concept of lipid rafts. In 1997, Eaton was made an EMBL Staff Scientist. In 2000, Eaton followed the so-called "gang of four"—Simons, her now husband Tony Hyman, Zerial, and Wieland Huttner—to Dresden, where they set up the brand new MPI. Eaton was named a Group Leader in Dresden and today directs a lab with a double focus on long-distance morphogen regulation and tissue polarization.

The Wandering Steinway

Dresden is now home to Eaton and Hyman, their two sons, Max, 9, and Luke, 7, and Eaton's wandering Steinway grand piano. "I'd been playing piano since I was eight, but the Steinway was a crazy purchase I made in San Francisco when I was living in an apartment about the size of the piano," she explains. With an irate law student living downstairs and threatening litigation if her playing impinged on his exam scores, Eaton knew she had to move it to safety.

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Eaton and Hyman shipped the Steinway first to Heidelberg, where it made apartment-hunting difficult, and then to a safe haven, at last, in the living room of their spacious old house in Dresden. Although the city is noted for its near- total destruction by Allied bombing in 1945, Eaton says that most residential sections were spared. Her pre-war house looks across ancient water meadows on either side of the River Elbe. The city center has largely been reconstructed since the 1945 bombing and 44 years of Communist rule. Today the city is particularly alive with music and opera, Eaton says. Dresdeners are unusually open to outsiders and extremely curious about the new MPI.

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Rack Pack Touring

Dresden seems a perfect fit for Eaton, says Rebecca Wright Heald, now at the University of California, Berkeley. Heald met Eaton when they were postdocs in different labs at EMBL in Heidelberg. "As much as I didn't want to go to Germany and hang around with Americans, that's where Suzanne became my best friend," Heald confesses. Their bond was cycling, and it was Eaton who talked Heald into buying her first high-tech road bike and then into taking her first long-distance, carry-everything-on-your-bike "rack pack tour." On their last road trip through southwestern France, Heald explains that Eaton was three months pregnant with her first child. "Her doctor said, 'No problem,' and we weren't doing crazy amounts, only 60–80 miles a day."

Parenthood has curtailed her friend's long-distance cycling, says Heald, but their relationship remains mostly about being friends, trading margarita recipes, or references to old "Star Trek" shows. Occasionally they'll talk science. The imaginal disc is not Heald's field, but listening to Eaton explain it is a dazzling experience for Heald. "The way she describes it is unique. She has this vision of these lipid particles carrying the signals. She figured out all these assays and learned all these really difficult techniques to show how they form a signaling gradient and patterning over distance. Suzanne is a lovely person, but her science is also lovely." ■