Growing Pains: Evo-Devo Researchers Straddle Cultures

For Kevin Peterson, a temporary job as a chauffeur turned out to be the start of a new career in science. As a Ph.D. student in paleobiology at the University of California, Los Angeles (UCLA), in 1992, Peterson was studying the evolution of animals with bilateral symmetry, which includes everything from insects to mammals. Then one day he was drafted to drive a prominent visiting paleontologist, Richard Jeffries, around Los Angeles to meet various local scientific luminaries. Peterson "sat meekly" on the sidelines as Jeffries and developmental geneticist Eric Davidson of the California Institute of Technology (Caltech) speculated about the genetics behind the five-sided symmetry of echinoderms such as starfish.

Paleo-polymath. Peterson leaped into lab work.

Peterson was so intrigued that he took a summer embryology course taught by Davidson, and in 1996, he moved to Davidson's lab as a postdoc, giving up fossils for the flasks and beakers of molecular biology. "In some senses, it was a big culture shock. But it's just a different way of going about things," he says. "Now I can test [hypotheses about evolution] in a laboratory as opposed to going out and—maybe—finding the right fossil."

Peterson is only one of a growing number of researchers crossing the gulf between evolutionary and developmental biology (see p. 34). But his story epitomizes the good luck and initiative needed to succeed in an interdisciplinary area that everyone agrees is hot, but that has little institutional infrastructure to support it. Researchers working in the interstices between the fields say they must spend years proving their skills in both disciplines before either side will take them seriously. Job openings, while on the rise, are still scarce. With little money set aside for studies of "evo-devo," grant proposals also face stiff competition from those in more established fields (see sidebar).

As with all unifications, the two parties' distinct cultures also create their own difficulties. Scientists in the two fields have different ways of thinking, speaking, and experimenting, and the divergent styles don't always mesh. For example, evolutionary biologists aim to track evolution's course across many species, while developmental researchers focus on the handful of model organisms for which advanced molecular techniques are available. Says Greg Wray, a developmental biologist at the State University of New York, Stony Brook: "Evolutionary biologists have the conceptual background [on evolution], but a lot of the time they don't even understand these data. Developmental biologists have the data, but they are not really up on what to do with it."

Differentiation. Acquiring training in both fields is the first challenge facing researchers who want to cross this gap. The ideal graduate curriculum, some say, would be evenly split between "evo" and "devo." But because no department or granting institution straddles this boundary, it is difficult—perhaps even dangerous—to obtain truly interdisciplinary training, established researchers warn. Young scientists must be able to sell themselves as straight developmental or evolutionary biologists if need be, says evolutionary biologist Jim Hanken of the University of Colorado, Boulder.

So scientists usually start out getting graduate training in one field, then make the leap into the other, often with a shot of serendipity, as Peterson's story indicates. UCLA molecular paleobiologist Charles Marshall has a similarly motley history. As an undergraduate in Australia, he studied math, physical chemistry, and geology. Then he moved to the University of Chicago, where he took biochemistry and molecular biology classes on the way to a Ph.D. in evolutionary biology. But one of the most crucial courses of his career was a 1-day paleontology course preceding the Geological Society of America's 1988 conference. UCLA paleontologists Bruce Runnegar and William Schopf needed a third teacher for the course and "caught wind" of his work. Eventually, they offered him a professorship at UCLA's Department of Earth and Space Sciences—where he now studies the development and evolution of the red flour beetle *Tribolium*, among other subjects.

Covering the field. Carroll's lab at Wisconsin includes developmental and evolutionary biologists.

Peterson argues that the Marshall plan—conceptual grounding in evolution first, followed by molecular techniques—is best. "I was very fortunate to be trained on the evolutionary side as opposed to learning it secondhand," he says. "To my mind, the tools of molecular biology can be learned fairly easily, but evolution and systematics are difficult." But Grace Panganiban, a new professor of anatomy at the University of Wisconsin, Madison, who studies limb evolution, feels equally lucky to have trained with a developmental biologist, UW's Sean Carroll. "We can't make much progress on the comparative side of limb evolution until we know more about the developmental mechanics," she says.

Either way, researchers making the leap from one area to the other are likely to encounter very different lab organization and leadership. In paleobiology, says Peterson, grad students are expected to come up with their own thesis ideas, data, and even theories, while in molecular work the principal investigator often runs the intellectual show. "It's not that graduate students in molecular biology don't think—it's just that the theory has often been done for them, and their job is to carry out the benchwork," he says.

The two sides even use terms differently. For evolutionary biologists, for example, two structures are "homologous" only when they have a shared evolutionary history. But developmental geneticists, like their cousins in molecular biology, apply the term to any genes that have similar sequences of nucleotides. "I go nuts sometimes when I hear molecular biologists talking about '60% homology' between two genes," says Peterson.

Growth. Once they have completed their training, young evo-devo researchers need a job. But finding an interdisciplinary post is often tricky, because a growing number of university biology departments focus either on molecular and cellular events or on whole organisms and ecosystems, rarely bridging these levels (*Science*, 14 March, p. 1556). In addition, each type of department has different priorities and values.

Departments of cell and molecular biology, explains Colorado's Hanken, often judge faculty candidates according to their facility with the most current molecular methods.

Evo-Devo Funding: Still Only a Trickle

Nearly everyone reaches for the same word to describe the available support for evo-devo research: scanty. "A lot of people I know are very interested [in evo-devo], but they can't get funding for it," says University of Chicago developmental biologist Mark Martindale. "[Evo-devo] is what we discuss over Friday beers, but when it comes to paying bills, people are more pragmatic."

Top developmental geneticists, such as Walter Gehring of the University of Basel in Switzerland, have little trouble persuading government funders to go along for the ride when their research unexpectedly veers toward matters evolutionary, as Gehring's did when the fly gene *eyeless* turned up across the animal kingdom. But many evo-devo researchers, particularly younger scientists in the United States, feel underfunded and charge that the obstacles are partly bureaucratic. Most evo-devo grant proposals fall between the jurisdictions of existing programs; as a result, they either aren't considered or are reviewed by two committees, says University of California, Los Angeles (UCLA), paleobiologist Charles Marshall. "That makes it much harder to pass muster," he says.

Officials at the major funding agencies insist that they look kindly on the field—although they admit they haven't the numbers to prove it. For example, Judith Plesset, program director for developmental biology at the National Science Foundation (NSF), says that the agency's support for evo-devo "is increasing naturally with the increasing excitement." But the foundation has never tracked numbers of proposals in the field. A recent search by *Science* of NSF's database shows that so far during the 1997 fiscal year (which will end 30 September), the three major NSF divisions handling evo-devo proposals—Molecular and Cellular Bioscience, Environmental Biology, and Integrative Biology and Neuroscience—have funded 18 proposals with abstracts linking them to both evolution and development. The funding so far totals $2.04 million out of the divisions' total 1997 budget of $251 million. Plesset calls this commitment significant but admits it "may not be enough" in the eyes of many researchers.

The other major source of funding for U.S. life scientists—the National Institutes of Health (NIH)—is often regarded as less welcoming. Martindale says he would never request an NIH grant for evolution work, because he's sure the review panel "would laugh me right out the door." University of Colorado evolutionary biologist Jim Hanken sympathizes. "Years ago, I called a program officer at NIH and said, 'I'm an evolutionary biologist, and is it OK if I put evolution into my proposal,' " recounts Hanken. "And he said, 'OK, as long as you don't put in too much.' I got the message."

NIH officials, however, insist that this is a misconception. NIH is "very interested in the relationships of evolutionary biology to the rest of science," says Irene Eckstrand, a program director at NIH's National Institute of General Medical Sciences. Yet the agency has a hard time backing up this claim with statistics. "Because of the fact that these grants are in a variety of programs and a variety of institutes, it's impossible to figure out accurately how much money NIH is spending," she says. A search of NIH's grants database reveals that the agency is currently funding 39 proposals indexed by the terms "developmental genetics" and either "evolution" or "biochemical evolution," but the haphazard nature of the database's indexing system probably makes this number unreliable, Eckstrand says.

It's safe to say, however, that passion in evo-devo outruns patronage, and some researchers have found private support to fill the gap. Spain's Juan March Foundation, for example, plans to sponsor an evo-devo congress in Europe later this year, and the U.S. Alfred P. Sloan Foundation has supported some young evo-devo researchers. For example, Grace Panganiban of the University of Wisconsin, Madison, got a Sloan fellowship to pay for part of her postdoctoral stint in the lab of development researcher Sean Carroll, as well as a young investigator award to pay for her research as an assistant professor at Wisconsin. But the Sloan postdoc program will expire in 1998.

For now, many leading researchers "piggyback the evolution end of things off their solid developmental biology grants," notes UCLA's Marshall. Carroll, who studies developmental genes in organisms ranging from fruit flies to sea urchins, agrees. He can only afford the needed infrastructure for his evo-devo studies, he says, because he is a fellow of the prestigious Howard Hughes Medical Institute; such fellows get an average of $680,000 annually for salary and lab setup. "That means I can attack slightly longer term, higher risk questions," says Carroll. **–W.R.**

"Yet you have to make some concessions when you do this evo-devo work," Hanken says, "because you are often working on species where you don't have a great database. Some departments might not regard it as appropriate work." By the same token, evolutionary departments may not be unduly impressed by fluency in advanced techniques—they want theoretical contributions, too. "There is a much greater importance of conceptual and theoretical work [in evolutionary biology] than there is for molecular biology," notes Günter Wagner of Yale University's Department of Ecology and Evolutionary Biology.

Out on a limb. Genetics led Panganiban to limb evolution.

Moreover, a developmental biologist looking for a place in an evolutionary department—or vice versa—may not have mastered the "right" organisms. Understanding evolution requires comparing genes across many different species, most evo-devo researchers agree. "If you want to understand the biological basis for the diversity of life, you have to study the diversity of life," says Mark Martindale, a developmental biologist at the University of Chicago. "It's not going to work to just study mice and fruit flies." But dissecting molecular pathways requires a species-specific set of genetic tools for each organism studied, such as libraries of complementary DNA fragments used to gauge the activity of genes from each species. That means working with standard lab organisms for which these libraries already exist.

All these are high hurdles, but a few institutional programs are stepping in to ease the way. Peterson, for example, is Caltech's first postdoc in "biogeology," a joint program of the biology and geology divisions; the program is also looking to hire a tenure-track researcher and is "designed exactly to operate in the interstices between molecular biology, geology, and evolution," says Caltech developmental biologist Eric Davidson.

In the end, even the most avid researchers admit that pursuing evo-devo means confronting one long series of such trade-offs. But the gains, they say, are worth the price. Says evo-devo leader Carroll: "My experience has been that when evolutionary biology and developmental genetics come together, great things happen."

–Wade Roush and Elizabeth Pennisi