ASSEMBLY WORK

Graduate students can be key links in interdisciplinary science, but training them for this role is a challenge, says **Brian Vastag**.

M. REYNOLDS/EPA/CORBIS

As a master's student in parasitology, Adriana Troyo became intrigued by dengue fever, a mosquito-borne disease that periodically flares up in her native Costa Rica. Troyo wanted to understand how geographical variation — such as urban tree cover — affected the disease's spread. She needed a PhD, but she wasn't sure which academic department would be best as her interests lie at the intersection of microbiology, epidemiology and geography.

So she entered an interdepartmental PhD programme at the University of Miami in Florida. There, she helped map ground-level mosquito data onto high-resolution satellite maps. The resulting 'risk maps' help guide country-wide mosquito-control efforts, says Troyo, now a professor of parasitology at the University of Costa Rica in San Jose.

For Troyo, becoming an interdisciplinary scientist was a natural move. But for many young scientists, boundary-busting can be daunting. Graduate schools and centres are still looking for the right ways to train a new generation of interdisciplinary scientists who can both speak the language of multiple fields and maintain enough expertise to take on cutting-edge problems.

Beyond the buzzword

'Interdisciplinary' has been a buzzword in science for at least 20 years. All manner of collaborations have sprung up — from pairs of researchers joining forces to state-of-the art dedicated facilities, such as Stanford University's Bio-X centre in Palo Alto, California, Arizona State University's Biodesign Institute in Tempe and Janelia Farm, a Howard Hughes Medical Institute centre that opened in Maryland in 2006.

That same year, the University of Manchester, UK, opened its Interdisciplinary Biocentre (MiB), a US$68-million building able to house 75 research groups and more than 600 staff. University College London's CoMPLEX programme, launched in 1998, is moving into a new building in May. In Germany, the Max Planck institutes' interdisciplinary efforts include an Institute for Dynamics of Complex Technical Systems in Magdeburg.

According to an unpublished survey, 25–30% of science and engineering faculty members at major US research universities report an affiliation with an interdisciplinary venture of some sort. Survey author Barry Bozeman, a professor of public policy at the University of Georgia in Athens, is trying to understand how working at interdisciplinary centres affects researchers' career trajectories. This is important because, until recently, administrators and researchers had learned little about how these centres operate, says Diana Rhoten, a programme director in the Office of Cyberinfrastructure of the US National Science Foundation (NSF).

Rhoten scrutinized the operations of six NSF-funded interdisciplinary centres. Her 2003 report, *A Multi-method Analysis of the Social and Technical Conditions for Interdisciplinary Collaboration*, concluded, in part, that graduate students were the 'bridges' between disciplines. This bridging was particularly stark at one centre: remove the graduate students from the network map and only single-discipline islands remained. "Pre-existing networks of scientists tend to cluster," says Rhoten. She is now wants to find out whether graduate students are merely running errands between faculty members, or whether they are really asking transdisciplinary questions and sparking collaborations. "I tend to believe it's a combination of both," says Rhoten. Young scientists are probably driving a lot of interdisciplinary collaborations.

Mike Wininger is a good example. He studied maths and physics as an undergraduate. But as a graduate

student he says he "wanted something more than just solving equations for the sake of solving equations — a more human element". So Wininger, a PhD student at Rutgers University, New Jersey, moved into biomedicine. He is now designing an image-processing system to sort healthy embryonic stem cells from unhealthy cells, bringing mathematical rigour to the process.

Two years of Wininger's graduate education were funded by the NSF's flagship interdisciplinary training programme, the Integrative Graduate Education and Research Traineeship (IGERT). The programme was launched in 1997 to "catalyse a change in graduate education". Some 150 colleges and universities hold five-year IGERT grants to train the next generation of interdisciplinary scientists. The programme is extremely competitive, with only about 5% of applying institutions winning funds, says programme director Carole Van Hartesveldt. A 2006 evaluation concluded that IGERT graduates had broader skill sets and were more oriented towards identifying and solving specific problems — advantages when hunting for jobs in industry.

Taking a risk

Arizona State University is striving to create a model even more innovative and potentially risky than IGERT, according to Neal Woodbury, co-director of the new interdisciplinary graduate programme there. Students in the programme, which welcomes its first class this autumn, will have no home department. And, modelled after an approach taken by the university's Biodesign Institute, studies are organized around pragmatic problems — for example, how to devise better renewable fuels — rather than a canon of science facts. Students will also be involved in seeking funding to develop their work. Woodbury says that, based on pilot interdisciplinary programmes at the university, this 'biological design' PhD is likely to attract applicants who would never have pursued a traditional PhD — for example, individuals sick of working in industry but who still want to solve big problems. The dozen students in the first class have backgrounds ranging from bioengineering to chemistry to physics.

Initial overview courses in interdisciplinary programmes are key. Students from different disciplines must quickly get up to speed in each other's fields. At the MiB, which has tracks in molecular bioengineering, systems biology and biological mechanism and catalysis, students in a four-year PhD programme — a year longer than the typical UK doctorate — initially have several months of lectures across fields such as mathematical modelling, analytical science and informatics. Second-year student Shichina Kannambath says that the first year of training was an essential base for embarking on her three-year PhD project, an imaging analysis of transcription factors in eukaryotes. The MiB has graduate programme funding only for the systems biology track, but its director, John McCarthy, hopes to get funding for the other tracks as well.

P. PRICE/SOCIAL SCIENCE RESEARCH COUNCIL

Diana Rhoten (top) and Barry Bozeman are trying to assess how interdisciplinary centres really work.

MIB

A new breed: the Manchester Interdisciplinary Biocentre.

Richard Zare, chair of Stanford University's chemistry department and a long-time interdisciplinarian, recalls his bitter experience in the 1960s as a young professor at the University of Colorado with joint appointments in physics and chemistry. "As an untenured faculty member, it was a trap," he says. "Each department regarded me in some sense as a spy from the other." He left after a few years. Although interdisciplinary work is gaining acceptance, old disciplinary silos still can impede and even discourage interdisciplinary aspirations.

Obstacles ahead

The risks of crossing departmental boundaries can be greatest for fledgling scientists. Tenure review committees can be a big obstacle, says Bozeman, as promotion criteria often fail to register interdisciplinary achievements. If a young researcher joins an interdisciplinary research centre, the fruits of such labour — as measured by publications, for instance — may not be readily apparent. "There is a sort of double jeopardy that goes on," says Alan Johnston, deputy director of the CoMPLEX programme. Physicists, for example, might not see the point of the biological aspects and biologists might not see the point of the physics elements, he says.

Arizona State's Woodbury, on the other hand, plays down the risks of a poor publication record for interdisciplinary students. Ideally, the students still specialize on some part of the interdisciplinary project, while staying part of the team, thus giving them a core expertise. "But you do have to train students not to take that problem and go into a corner and never come back," Woodbury says. When studying the NSF centres, Rhoten found that researchers reported publications as a less important benefit than the intellectual change they were experiencing.

Woodbury is, however, a bit wary of how a PhD in biological design might be perceived by employers. "We might have to modify our approach on the basis of how the students do," he says. And Johnston notes that the shifts in research discipline that many interdisciplinary students undergo can make it harder to find postdoc positions.

McCarthy is concerned about finding even-handed interdisciplinary peer review among funding bodies. He and others have commissioned a report from the Royal Society of Chemistry on the topic, focusing on the interface between chemistry and biology. Due to be released soon, the report finds in part that UK funding bodies have improved in this regard, but could get better. The US National Institutes of Health is considering forming review panels geared to evaluating interdisciplinary research proposals.

Regardless, graduate students are likely to continue to act as the cement in interdisciplinary partnerships. "They don't know enough initially to be afraid of all the disciplinary problems of making programmes like this work," says Woodbury. ■

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