TURNING POINT Computer scientist models global ecology **p.373**

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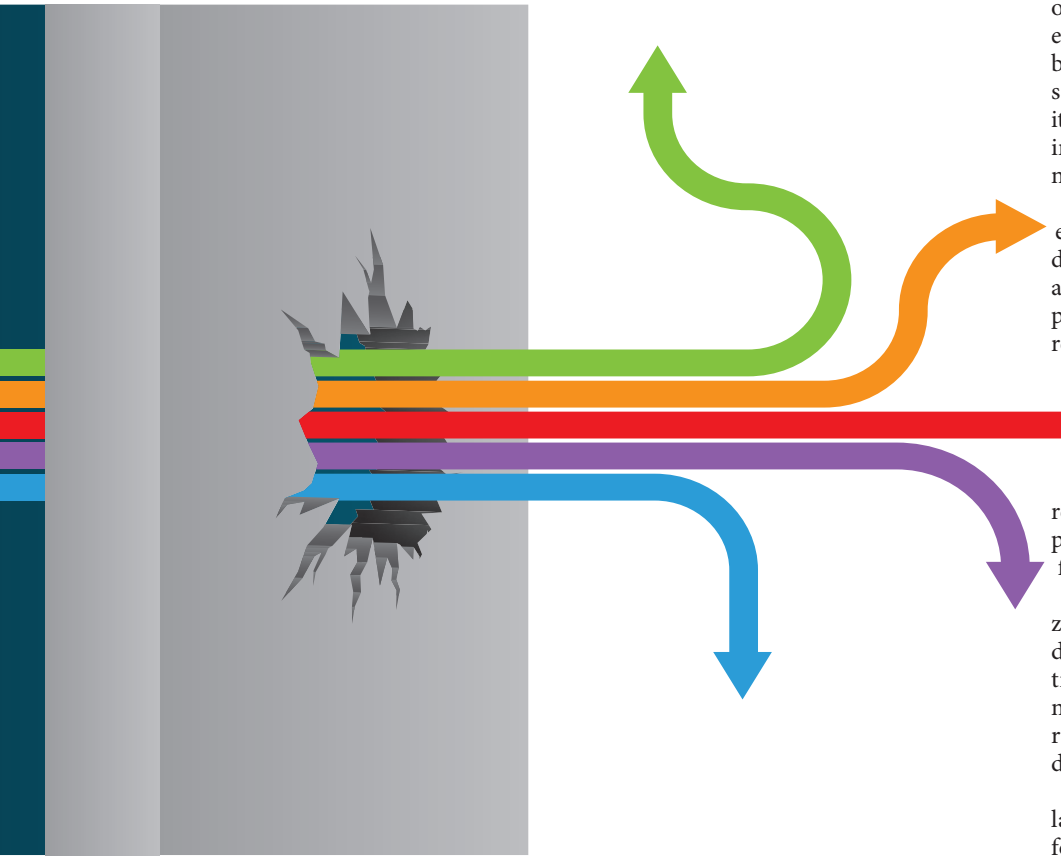

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INTERDISCIPLINARY RESEARCH

Break out

Researchers working at the interface of disciplines can pursue insights without sacrificing career progress.

BY VIRGINIA GEWIN

Compostable electronics, bacterial communication and forced-migration prediction. These seemingly unrelated research topics have underlying similarities: they are all examples of solution-oriented projects that require a broad cross-section of expertise.

Interdisciplinary research is starting to attract more and more attention — and funding. This year, for example, the US National Science Foundation (NSF) has requested US$63 million (210% more than in 2012) for its INSPIRE (Integrated NSF Support Promoting Interdisciplinary Research and Education) awards programme, which supports research into complex scientific problems such as space-weather monitoring, groundwater restoration and epigenomic analysis of single cells. In an era of stagnant, even shrinking, research funds, such budding fields can be a shrewd choice, especially for early-career researchers.

Interdisciplinary research pulls together disparate expertise to advance an emerging field or solve a multifaceted problem. Nanotechnology, for example, requires knowledge of chemistry, biology and physics, and disease control can involve molecular biologists, biostatisticians, public-health officials and sociologists. Environmental science, with its study of entangled ecosystems and policy impacts, is the quintessential interdisciplinary field.

And, like the United States, the UK government has now dedicated funds to interdisciplinary research (see 'Interdisciplinary aid'). Research Councils UK (RCUK), the partnership of all seven publicly funded UK research councils, has identified six priority research areas, including energy and global food security, and in 2012 it joined with funding agencies from other nations in a €20-million (US$27-million) initiative to support research on multinational, multidisciplinary problems, such as coastal vulnerability and freshwater security.

Funding agencies are not the only organizations to encourage young scientists into discipline-spanning research. Universities are making structural changes to promote and accommodate interdisciplinary research, most notably by creating interdisciplinary centres or institutes.

Last year, Stanford University in California launched a neuroscience institute and one for chemical biology, bringing the number of interdisciplinary laboratories, centres and institutes to 18. Heriot-Watt University in Edinburgh, UK, restructured in 2012 into 9 engineering and science institutes and 20 multidisciplinary centres, for areas such as sustainable-building design; sensors, signals and systems; and ocean systems.

MEASURE OF METRICS

But interdisciplinary research can have downsides. Perhaps counter-intuitively, interdisciplinary researchers must carve out a speciality, to form a coherent body of work from disparate strands. This can be difficult if the goal is innovation rather than getting work published, and evaluation metrics can be a major pitfall. Publications in high-profile journals are still the main scorecards for tenure and promotion decisions in many countries. In the United Kingdom, high-profile publications submitted from each researcher are the basis of comparison for the Research Excellence Framework, a government assessment that takes place every six years and establishes university funding levels. Because the evaluation weights ▶

research outputs (in the form of high-profile publications) at 65% of the total score, interdisciplinary research is liable to garner fewer funds under these discipline-focused standards.

The result is a large gap between the growing number of incentives to conduct interdisciplinary research and the level of career advancement it can offer. Even securing a junior interdisciplinary post is fraught with difficulty (see *Nature* **476,** 115–117; 2011), and career advancement for non-traditional research output poses even more challenges.

Stephanie Pfirman, a polar researcher with a joint appointment at Barnard College and Columbia University in New York city, can attest to the difficulties. Her interests in policy issues were stymied early in her career when her mentors and others consistently advised her to defer her ideas until she was more established. Given the challenges of becoming too broad too soon, she thinks it was good advice, but her experience led her to craft a report entitled *Interdisciplinary Hiring and Career Development: Guidance for Individuals and Institutions*, which was published in 2011 through the National Council for Science and the Environment (see 'Quick tips').

GROW STRONG AND BROAD

Interdisciplinary researchers have varied interests, so their work is published in journals that span different and sometimes unrelated disciplines. And yet academics are most likely to advance when their expertise is easily identifiable. What to do? Pfirman says that interdisciplinary academics should think of themselves as a tree: a researcher needs to have a main trunk of ideas, but also put out roots and branches that can connect to others. She points to Solomon Hsiang, an environmental scientist at the University of California, Berkeley, who was a lead author of *Risky Business: The Economic Risks of Climate Change in the United States*, a high-profile report released in June. Hsiang combines large, independent sets of social-science, meteorological and climatological data with statistical methods that are more commonly used in microeconomics than in natural science. "I can give the same talk using the same data to climate scientists and to microeconomists, but they will look very different," he says. He reckons that he almost did the work of two PhDs to get to the point of being a go-between in these fields. But it paid off in that it enabled him to do innovative research.

"If you try to be everywhere, you may not get traction anywhere."
Stephanie Pfirman

"One of the challenges of conducting interdisciplinary work is that it's not always obvious which academic department is the best fit," says Simon Goring, a postdoctoral researcher studying palaeoecology at the University of Wisconsin–Madison. He, for example, is based in the geography department, but says that his research on continental-scale ecological patterns could just as easily be classed as biology.

A home department will want to evaluate someone on the basis of their contributions to the core discipline of that department, says Laura Meagher, senior partner at Technology Development Group, a company based in Fife, UK, that advises higher-education institutions and research agencies on how to make strategic changes. Meagher once interviewed a department chair about the interdisciplinary postdoctoral fellows coming through his department. The chair raved about the quality of their research and ideas, but admitted that he probably wouldn't hire one because he needs faculty members who can teach the department's introductory courses.

Perhaps the biggest professional concern for an interdisciplinary researcher is whether discipline-based tenure committees can adequately evaluate the impact of their work. Such committees often place substantial weight on external letters of support from knowledgeable faculty members at other institutions. Priyamvada Natarajan, an astronomer at Yale University in New Haven, Connecticut, describes how the dilemma could play out for a biophysicist who works on fluid flow, for example. It is possible that letter writers end up being biologists who may not fully appreciate the research contributions, rather than physicists who work on fluid flows, she says. "Those types of situations can result in tenure surprises."

SET PRIORITIES

One way to ensure career advancement is to understand how university administrators measure success. Michael Binford, who studies land-use change at the University of Florida in Gainesville, notes that interdisciplinary researchers in productive groups should end up with more papers. But to ensure enough lead authorships, he says, they should carve out their own contribution and turn that into a paper.

Tenure committees may overlook some outputs of an interdisciplinary researcher, especially if it is a computer program or statistical tool. In a paper published in February (S. J. Goring *et al. Front. Ecol. Environ.* **12,** 39–47; 2014), Goring and his colleagues raised their concerns about being evaluated according to traditional success metrics, and said that tenure committees should be encouraged to value data-set creation, blogs, social media and policy-relevant activities.

Meagher emphasizes that it is essential for interdisciplinary scientists to highlight their unique abilities. "Don't be afraid to say that you enable people to work together across teams and perspectives," she says, adding that the teams that win interdisciplinary grants are the ones whose members make it clear in the proposal that they will spend time building trust and learning each other's languages.

Researchers who seek academic employment should evaluate an institution's track record of supporting and valuing interdisciplinary research before they accept a position there, says David Hassenzahl, newly appointed dean of California State University's college of natural sciences in Chico. He points, for example, to a tool called STARS (Sustainability, Tracking, Assessment and Rating System; https://stars.aashe.org), which was put together by the Association

INTERDISCIPLINARY AID

Funders and institutions show their support

The University of Southern California in Los Angeles is one of the few US institutions that has amended its promotion and tenure guidelines for interdisciplinary faculty members. In 2011, it allowed evaluation committees to consider letters of support from a mix of departments, and last year, it provided guidelines for assessing academic output beyond journal articles — including enhanced data sets, software and collaborative tools.

Funders are also encouraging interdisciplinary collaboration. Scottish Crucible, a scheme launched in 2009 and financed in part by the Scottish Funding Council, provides a three-month leadership and communication training programme for 30 participants selected from wide-ranging disciplines.

The scheme offers a sort of 'speed dating' venue for participants, encouraging them to share their work with one another and to pursue potentially interesting partnerships.

At the end, participants can submit proposals for collaborative projects.

Versions of Scottish Crucible are popping up elsewhere in the United Kingdom: there is now a Welsh Crucible and a South West Crucible. **V.G.**

QUICK TIPS

Navigating disciplines

Stephanie Pfirman, a polar researcher at Columbia University in New York city who has published a report on how to handle interdisciplinary-research issues, suggests four ways that can help researchers to carve out their niche.

- Make sure that your CV spells out your contribution and how it was integral to the overall project.
- Attend the most relevant meeting in your core discipline and run a session on your topic to highlight its importance and to help spur connections.
- Indicate your academic reach. Include a link to your Google Analytics web page, for example, and use it as a citation index because it illustrates impacts more broadly.
- Expand your network by making contact with authors of papers that cite yours. **V.G.**

for the Advancement of Sustainability in Higher Education in Denver, Colorado, to identify universities and colleges that give interdisciplinary research the same weight as traditional disciplinary research.

There is also no escaping the fact that interdisciplinary research spans not just different disciplines but different academic cultures. Researchers often end up in joint appointments — a faculty position that reports to two departments. Such positions can be risky because the person is effectively serving two masters, who may have differing views on the achievements needed for tenure.

One strategy is to cultivate a large network in both fields, but some researchers caution against spreading their efforts too thinly. "If you try to be everywhere, you may not get traction anywhere," says Pfirman. That said, she adds, visibility and recognition are crucial for early-career scholars. Young scientists should focus their efforts on a big disciplinary meeting that is close to their interdisciplinary speciality, she says, and make a name for themselves there.

Ultimately, any career arc needs to tell a coherent story. Early-career researchers need to make clear how their work ties together into a "meaningful, original research agenda", says Hassenzahl. "That's what academia is all about." ■

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TURNING POINT
Drew Purves

Drew Purves, who heads the Computational Ecology and Environmental Science group at Microsoft Research Cambridge, UK, published the first-ever mechanistic general ecosystem model in April (M. B. J. Harfoot et al. PLoS Biol. ***12,*** *e1001841; 2014). This tool simulates the interactions of all organisms on Earth and the underlying ecological mechanisms that govern biodiversity patterns, which may help to predict how invasive species or pollution shape the world.*

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How did you tackle the ecosystem model?
Stephen Emmott, our head of computational science, likes to take a broad-sweep approach to science. One day he asked: "Why don't we model all life on Earth?" I was sceptical, but I like a challenge, and we wanted to do something that would be useful for the conservation community. It took four years, and the model turned out to be unusual — we couldn't model every individual species, so the key development was figuring out how to properly simulate nature using realistic and rigorous approximations.

Are you a geek at heart?
Yes. I got into computer programming when I was 7 — I got a Commodore 64, one of the first home computers. Around age 14, I watched a documentary about artificial life, and started reading about how to simulate life through a computer. Looking back, I realize now that my interest as a student in examining real-life processes of ecology and evolution at the University of Cambridge evolved from my interest in studying artificial life.

How did your postdoc shape your career?
In 2001, I was lucky enough to get a postdoc with ecologist and evolutionary biologist Stephen Pacala at Princeton University in New Jersey. He had just become director of the Princeton Environmental Institute, which had support from the global oil company BP and the US car manufacturer Ford. As a result of working with him, I met several senior executives from these companies who wanted to do cool and risky stuff, such as carbon capture and storage. After meeting them, I was more open to considering the Microsoft research job when it came up. Before I had those experiences, I had presumed that big corporations were evil and only out for profit.

What convinced you to go for the Microsoft job?
The job advertisement sounded ambitious. They said they wanted a computational ecologist, a phrase I had never heard before, but it sounded like what I wanted to do. In many ways it didn't make sense to take this position when I was starting to get offers to do the academic jobs I had trained for. But I rationalized that there would always be university jobs available.

How does this position differ from an academic research job?
There is no predefined idea of success here. There is an expectation that what we are doing will have an impact on society, but that impact could take the shape of high-profile publications or software development that could enhance the field of computational ecology. It makes me weep that in academia we take the cleverest people in society and rank them on a single dimension — their publication record. At Microsoft, we do not have to pursue predefined ideas. I can follow my interests — helping humanity to achieve a better understanding of nature and the biosphere we all depend on. My group is a small team with limited resources, but we take on big projects, such as predictive modelling of global agriculture.

Where do you go from here?
I want to run more scenarios to see how well real-world data fit our model and to try, for example, to predict outcomes under different climate conditions. I'll use the results to explore interesting applied questions as well; for example, I would like to simulate Australia's cane-toad invasion. We need to find ways to sufficiently connect our models to existing data; with enough of those links, we can put realistic limits on the model to learn how and where it works best. In my darkest moments, I wonder whether this is still science. But surely it's science in the same way that we model how galaxies formed? ■

INTERVIEW BY VIRGINIA GEWIN