Abstractions

FIRST AUTHOR
Predicting whether a non-native invasive plant species is likely to overtake a given ecosystem can be tricky. But being able to make such predictions would be valuable, because invasive species can have serious ecological and economic consequences. Researchers generally believe that invasive plants thrive best when resource levels — nutrients, water and sunlight — are plentiful. But as an undergraduate visiting Hawaii, Jennifer Funk, now a postdoc at Stanford University in California, found this puzzling. Despite having low-nutrient volcanic soils, the islands are overrun with invasives. She and colleague Peter Vitousek compared the resource-use efficiency of 19 invasives with that of 19 evolutionarily related natives. They report, on page 1079, that invasives are as efficient as or more so than native plants at using limited resources. Funk tells *Nature* about her trek across paradise to study these plants.

Why have there been so few studies of invasives in low-resource environments?
Most invasive species are found in disturbed habitats, which are often characterized by high resource availability. For example, if you harvest some of the trees in a forest, you increase the amount of light available to the remaining trees and plants. Research in disturbed systems suggests that invasive plants are able to exploit high-resource conditions. But it's widely thought that natives in low-resource environments should be able to outcompete invasives, because the natives have traits that allow them to persist there.

How did you decide which species to look at?
I used evolutionarily related pairs of native and invasive plants, comparing an invasive and native plant from either the same genus or the same plant family. Closely related species have more traits in common, which makes it easier to identify the trait or traits making an invasive plant more aggressive.

How did you determine the performance of natives versus invasives?
We looked at resource-use efficiency, which is the amount of carbon that a plant assimilates through photosynthesis per amount of resource used to acquire that carbon.

What further studies might help determine better ways to manage invasives?
It would be interesting to look at how resource-use efficiency operates at different phases of invasion. For example, if a grass invading an arid environment has very high water-use efficiency, you might want to target the removal of that invasive plant before it becomes problematic, because it's likely to outcompete the native vegetation for the most limited resources. ■

MAKING THE PAPER

Scott Manalis

Microfluidics boosts the resolution of tiny mass measurements in liquid.

Finding ways to make very sensitive measurements of biological molecules has long been of interest to Scott Manalis's group at the Massachusetts Institute of Technology in Cambridge. But they didn't want to use fluorescent or radioactive labelling techniques that require multistep sample preparation methods and relatively large sample volumes. "We wanted to develop methods for label-free detection that could be as sensitive as fluorescence," says Manalis. One way of detecting molecules is by their mass. But how do you weigh really tiny things?

Nanoscale mechanical resonators can measure the mass of particles weighing as little as several zeptograms (a zeptogram is 10^{-21} grams). These instruments are designed to vibrate at a given frequency, known as the resonant frequency. When a molecule lands on the resonator's surface, the resonant frequency changes by an amount that correlates to the mass of the molecule. However, these instruments do not work as well when they are placed in a solution, because fluids dampen the mechanical vibrations. This often limits their biological applications, because these frequently require fluid.

In 2002, Manalis and his team came up with an approach to overcome the problem. Why not try putting the fluid in microchannels inside the resonator? Thomas Burg, a graduate student in Manalis's lab at the time, set about making a prototype. Although it worked, it didn't take very sensitive or reliable measurements. This was partly because Manalis and Burg had not been able to make it in such a way that it could be contained within a vacuum, one of the requirements for measuring really small weights. "A well-known challenge in the MEMs [micro-electro-mechanical systems] field is packaging," says Manalis. "In many cases, the details of packaging are known only by the graduate student who developed the process. Once the student graduates, it can be difficult to advance the project beyond the initial demonstration."

To prevent this from happening, Manalis joined forces with the Santa Barbara-based labs of Innovative Micro Technology (IMT), a Californian company with expertise in manufacturing MEMs. "Collaborating with IMT has given us access to state-of-the-art packaging and microfluidic processes that have allowed us to develop highly robust and sensitive mass detectors," says Manalis. Burg, who had by this time almost completed his thesis, decided to continue on the project as a postdoc. After about three years' further development, the group had a vacuum-packaged resonator that could weigh individual nanoparticles, single bacteria and protein monolayers in solution with a resolution of 10^{-15} grams (see page 1066).

In addition to weighing particles that bind to the sides of the channels, the instrument can measure samples as they flow through it. The idea of designing the instrument in this way came about almost by accident. "Once the device had been designed with three-micrometre-tall channels, it occurred to us that we could flow bacteria through them and weigh individual cells one by one," says Manalis. Using this flow-through mode, they could weigh a wide variety of particles, as ways to bind particles to the instrument's surface were not needed.

The instrument works better than Manalis and his co-workers could have ever anticipated, but the proof lies in what it will be able to do. "We know we can weigh nanoparticles and cells. Now we need to focus on useful applications," says Manalis. ■

KEY COLLABORATION

What's the best that can happen when a scientist sits in on a course from another discipline? For Robert MacPherson, a mathematician based at Princeton in New Jersey, and materials scientist David Srolovitz, it led to a collaboration that hit a theoretical jackpot and has broad practical applications.

"Bob attended my graduate course at Princeton because he'd heard there were some great geometry problems in materials science," says Srolovitz, now dean of Yeshiva University in New York. MacPherson's hunch proved correct when Srolovitz spoke about the von Neumann grain growth problem, which predicts how cells grow in two dimensions but can't describe how they grow in three.

Within months they were able to take some abstract concepts from geometric probability theory and measurement theory to evaluate the integral curvature in three dimensions (3D). "After we saw that the idea worked in 3D and reduced to the von Neumann 2D result, we realized the solution could be extended to all dimensions," Srolovitz says (see page 1053).

But perhaps the most valuable result of their collaboration is the identification of a quantity they term the 'mean width', a 1D measurement that they believe will become the standard measurement of length or size for 3D objects. ■