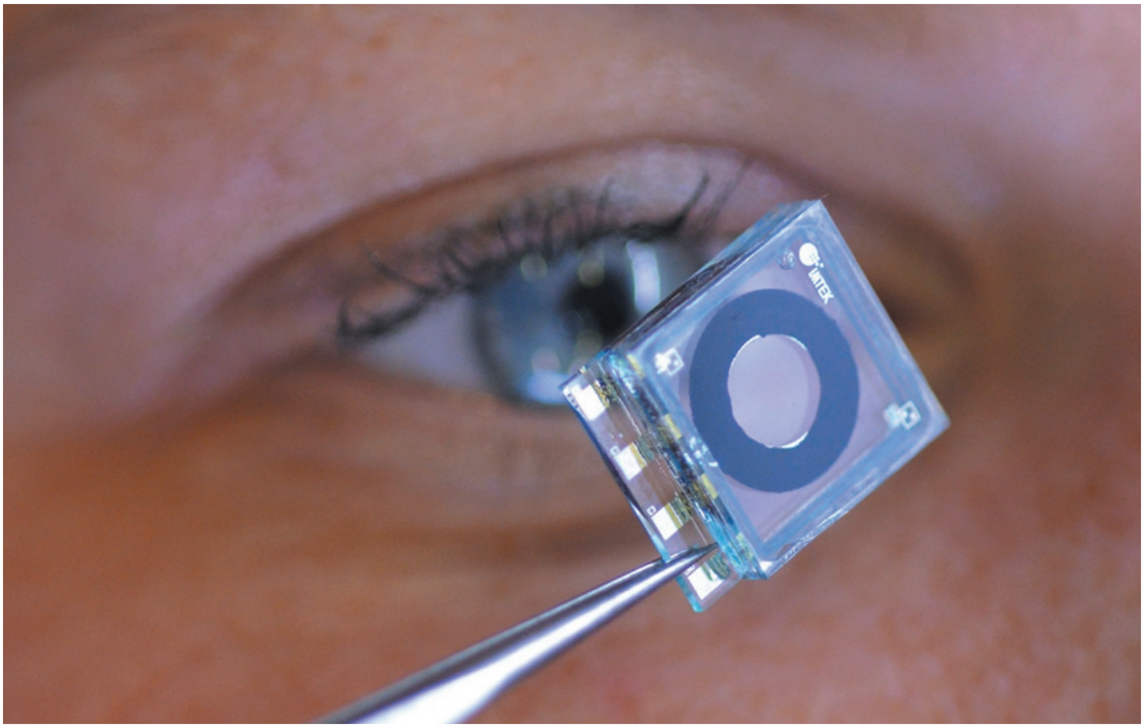
COMMENT

LABORATORY FOR MICRO-OPTICS UNI. FREIBURG



Optofluidic chips must meet demanding industry specifications before making it to market.

Bridging the market gap

Physicists and engineers must do more than peddle ideas if their technologies are to translate effectively beyond the lab, says **Hans Zappe**.

Earlier this year, I witnessed a scout from a consumer electronics firm visiting a university lab to assess a prototype optical chip for potential investment. Holding the fluid-filled device between his fingers, and with an eye on the postdoc who had produced it, the visitor gently shook it. Nothing happened. He shook it more violently. Still no leaks. The postdoc smiled. The scout threw the chip to the floor. Coolly, the researcher picked it up, placed it under a microscope and showed the guest that it still worked perfectly. The prototype was surely well advanced.

The researcher's smile faded some weeks later, when a development contract from the electronics firm arrived in the post. The contract made it clear that the two parties had disparate views on what they considered to be advanced. The industrial partner imagined paying for 100 fully characterized and functioning samples and instructions on how to make them — to be delivered as soon as possible. The university partner looked at the long list of specifications, ranging from sub-freezing storage temperatures to device lifetimes measured in years, and realized that much more effort would be required. Only then did the difficult development work begin: setting out a detailed programme in which the performance of the chips could be tested, assured and delivered.

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It is a familiar tale. Although translational research is established in biomedicine, yielding many commercial pharmaceuticals (see *Nature* **453,** 830–831; 2008), technology translation is still a big problem in the physical, chemical and biological sciences, and in engineering (see 'Patent problem'). There can be a yawning gulf between an exciting result that is suitable for a paper in *Nature* or *Science*, and its realization in a form that allows a company to begin product development. For example, some advanced miniaturized optical-imaging systems for medical diagnostics have yet to find manufacturers, even five or more years after the concept has been proven.

The technology-translation gap exists ▶

for many reasons: cultural, institutional and technical. To bridge it, universities and companies must better understand each other's needs, motivations and limitations. The fastest way to close the gap is to spend more time together in each other's labs.

DIFFERING VIEWS

The cultural barriers to technology translation are ingrained in both camps. Companies would like universities to distribute the fruits of their research free of charge, because, after all, much of the work has been paid for with public money. Engineering departments, in their view, should focus on developing prototypes that can be manufactured on a large scale, and not 'waste' time with blue-sky research that has no obvious commercial value.

In many university departments, by contrast, industrial collaboration is regarded with suspicion. Academics shy away, fearful that companies will influence research directions and covet useful results.

In the United States, reluctance to partner with industry began to thaw with the passage in 1980 of the University and Small Business Patent Procedures Act, known as the Bayh–Dole Act. The act allowed government-funded educational institutions to retain the titles to their patents. Universities discovered a lucrative source of funding, and technology-transfer offices sprouted up like mushrooms on US campuses.

Other countries followed suit, but did not always see the same results. The equivalent law enacted in Japan in 1999 boosted the number of research-and-development projects between national universities and private industry from 56 in 1983 to 14,303 in 2008 (ref. 1). But in Germany, which already had a tradition of assigning patent rights to the inventing faculty member[2], the passing of similar legislation in 2002 led to stagnation in patent activity[3], because some researchers held back their patentable ideas.

To improve matters, universities that are keen to build up their patent portfolios need to provide more incentives for individual academic researchers to engage with the technology-transfer process, which can be tedious and expensive. Compared with publications, patents carry little weight in most academic evaluations. To establish a 'patent culture' on campus, policies, rules, rewards and ethos must support faculty involvement in business activities[4].

Culture alone may explain why electrical engineers at Stanford University in California, for example, have 50% more corporate affiliations (253 in 2004) than their colleagues at the University of California, Berkeley (168 in 2004), even though the departments are similarly sized, both rank in the top few in the United States and both are close to Silicon Valley[5]. Whereas Stanford — the alma mater of the founders of Google, for instance — has a strong tradition of valuing such activities, the University of California system is more ambivalent.

"Diverging technical expectations mar many industrial–academic relationships."

Even when campus culture supports entrepreneurship, there is often a further hurdle: the unrealistic financial or intellectual-property expectations of a university's industrial liaison office. Inspired by a few industrial geese who did lay golden eggs, the lawyers in many university technology-transfer offices have scared off potential collaborators by demanding too much. Whether these offices foster or hinder fruitful collaboration is controversial[6]. In my experience, their utility varies strongly with the personalities and qualifications of their staff.

As in the opening tale, diverging technical expectations mar many industrial–academic relationships. 'University prototypes' and 'industrial prototypes' are distinct. University researchers love to pursue wild ideas and to artfully perform difficult experiments that, even if challenging to reproduce, need only work a few times to yield a high-profile paper that could advance their academic career. For the industrial researcher, a device has to work every time, with well-understood reliability, reproducibility and lifetime.

Speed is another issue on which industrial and academic partners do not see eye to eye. Academics take a long view, with typical projects lasting a few years — long enough to complete a PhD. Industrialists run a tighter ship, with stringent deadlines set by company financial-reporting timescales and market competition, often measured in months. Releasing a product onto the market a year after a competitor's is simply not an option.

"Business success for a product — the return on research investment — must take place within three years for a manager to profit from it," nanotechnologist Robert Brunner told me; he joined the University of Applied Sciences Jena in Germany in 2010 after many years in industry. "A proof of principle is not enough; a market-ready product must be there." Agreeing on timeline expectations is as essential as agreeing on technical specifications.

So, is there any use in all the science parks and technology 'hatcheries' with which universities have tried to attract companies onto campus? I think not, although evidence is equivocal. Science parks provide infrastructure for companies, especially for start-ups. But the celebrated 'proximity-to-campus' is usually only physical, with little real promotion of intimate collaboration between people.

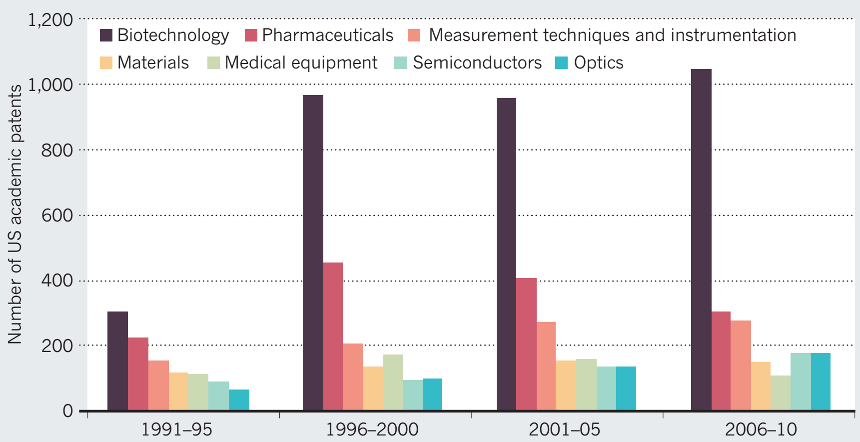
For example, the Engineering Research Centers (ERCs) initiated by the US National Science Foundation in the 1980s to encourage cross-disciplinary research failed to live up to expectations, owing to insufficient participation by both industry professionals and academics. Almost 70% of engineers surveyed felt that the ERC objective had been poorly met or had no impact on industry[7]. Proof of Concept Centers[4], the latest campus approach implemented in the United States, are intended to provide a spectrum of services to help to disseminate technology from university to industry. But the centres await a precise definition of their role.

WORK TOGETHER

To stop promising technologies languishing on laboratory shelves, universities need to realize that industry is not a rapacious octopus, sucking up everything it can get its tentacles on and suffocating the scientific independence of academic researchers. Patents and industrial research should be valued more highly in faculty evaluations, and university liaison offices must be willing to

PATENT PROBLEM

Physical-sciences patents in the United States have increased, but biomedical inventions still dominate.



SOURCE: US NSF/THE PATENT BOARD

THOMAS KITCHIN/VICTORIA HURST/GETTY

sell emerging technology and intellectual property at a reasonable cost to support product development. Academics must realize that just sending off a progress report after cogitating in the laboratory is not useful for a company.

On the other side, industry must appreciate that universities are not buffets of fully mature technologies there for the taking, free of charge. Companies should expect to invest time and money to move from an academic prototype to a commercial product. Industrialists must acknowledge that repeated measurements of reproducibility, lifetime and reliability are difficult to fit into the academic framework of constant innovation, and are not the best use of researchers' skills.

What both partners need from each other must be made clear at the outset. As Olav Solgaard, an electrical engineer at Stanford, explained: successful collaborations require leaders on both sides to manage expectations and to set sensible ground rules. Both must agree on outputs such as publications, especially when PhD students are involved. Simple and direct approaches are necessary. Many universities in China, for example, are involved in managing the companies with which they collaborate[8]. Others find that integrating industrial researchers into university laboratories is effective.

Hiroshi Toshiyoshi at the University of Tokyo, who has a long record of developing microelectromechanical systems and collaborating with industry told me how he likes to operate: "I like to ask my partner company to send their researchers to my group, where I give theoretical and on-the-job training for a year or two. We may not be able to deliver immediate results, but the company will obtain long-lasting competence."

So, set aside some lab space, fill it with recent graduates and company researchers, shake well and let the nutty academic idea evolve into the useful industrial prototype. ■

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An endangered Florida panther population was bolstered through hybridization with a related subspecies — a technique that could be refined using genomic tools.

Gene tweaking for conservation

It is time to weigh up the pros and cons of using genetic engineering to rescue species from extinction, say **Michael A. Thomas** and colleagues.

Even the most conservative estimates predict[1] that 15–40% of living species will be effectively extinct by 2050 as a result of climate change, habitat loss and other consequences of human activities. In the face of such drastic losses, scientists are debating the pros and cons of various, and often controversial, interventions. These include moving populations to help track hospitable habitats, and reinstating keystone species — those that have a large effect on ecosystem structure and function, such as top-level predators — into areas where they have long been absent[2,3]. Even the revival of species that have recently gone extinct is being explored.

So far, an increasingly viable (and potentially less risky) option, which we call facilitated adaptation, has been little discussed. It would involve rescuing a target population or species by endowing it with adaptive alleles, or gene variants, using genetic engineering.

Over the past 30 years, genetic engineering in agriculture has received substantial attention. Today, 12% of arable land worldwide is planted with genetically modified (GM) crops; the GM seed market alone is valued at US$15 billion. As techniques become ever more sophisticated, more possibilities will open up.

We believe that these combined factors mean that conservationists will almost certainly be tempted to apply genetic engineering to safeguard biodiversity. Facilitated adaptation might be less logistically challenging than moving entire populations, and less fraught with ecological and socio-economic complications — relocation could introduce harmful invasive species, for example, or unleash outbreaks of disease. But facilitated adaptation is likely to be beset with other challenges and pitfalls. Now is the time to consider what those might be.

THREE OPTIONS

There are at least three ways to avert extinction using facilitated adaptation. First, animals or plants from a threatened ▶