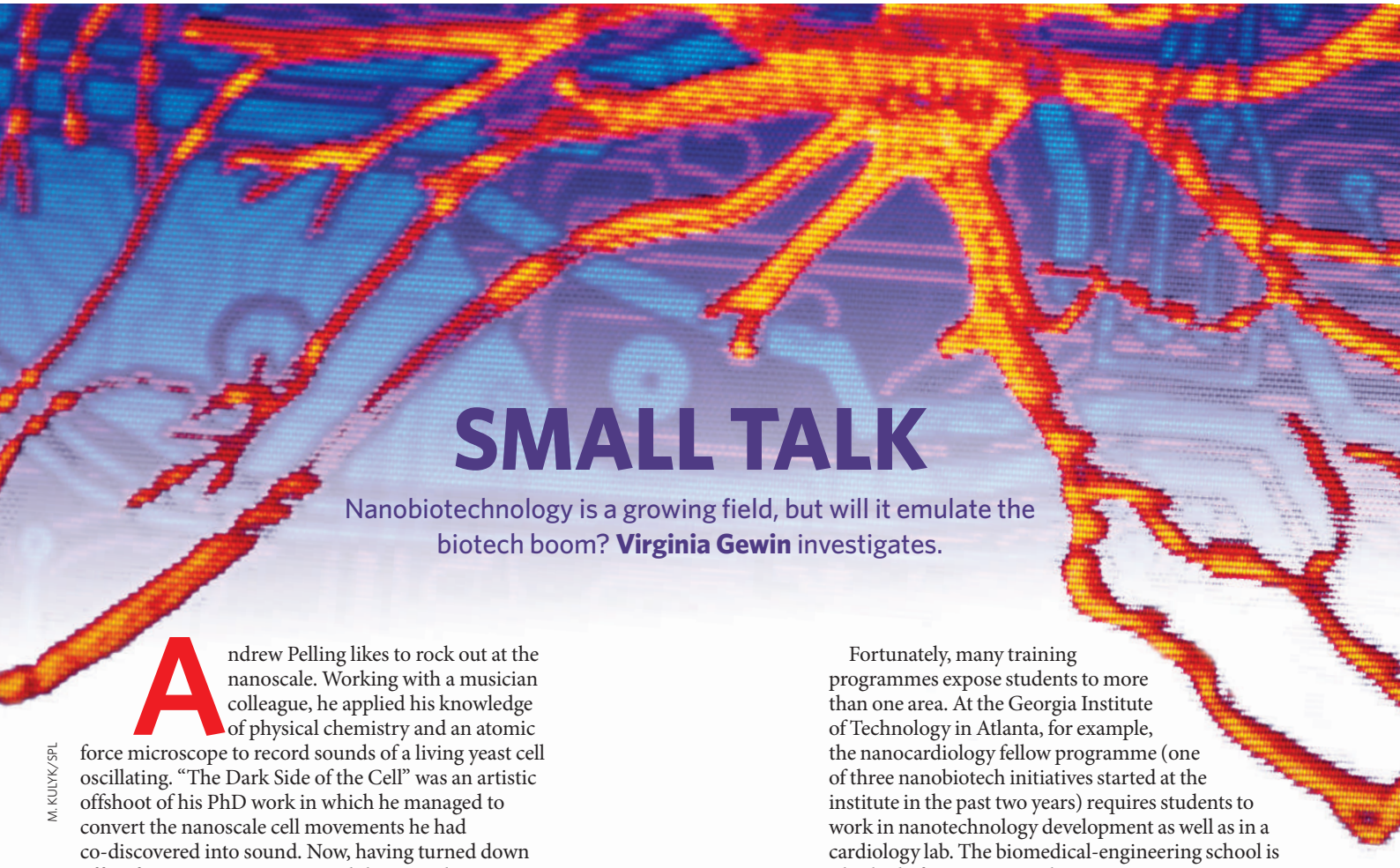

M. KULYK/SPL

SMALL TALK

Nanobiotechnology is a growing field, but will it emulate the biotech boom? **Virginia Gewin** investigates.

Andrew Pelling likes to rock out at the nanoscale. Working with a musician colleague, he applied his knowledge of physical chemistry and an atomic force microscope to record sounds of a living yeast cell oscillating. "The Dark Side of the Cell" was an artistic offshoot of his PhD work in which he managed to convert the nanoscale cell movements he had co-discovered into sound. Now, having turned down offers from Germany, Japan and the United States, Pelling is pursuing his research on cell mechanics at the new London Centre for Nanotechnology at University College London.

Like most students attracted to the nanoscale realm of biotechnology, Pelling uses a range of skills to cover new ground. Nanobiotechnology develops tools to explore the molecular mechanisms behind biological processes. With technology reaching the actual scale of biological events, three areas — drug-delivery systems, diagnostics and therapeutics — have come to the fore.

Local and national governments in the United States, Germany, Britain and Japan are providing money for nanobiotechnology research and development initiatives. The US$1.6-billion National Nanotechnology Initiative in the United States, Japan's US$1.1-billion investment and some US$4.5 billion earmarked for nanoscience in the European Union are creating the research and training infrastructure needed to boost the field. By some estimates, two million nano-savvy workers will be needed in the next decade. Training opportunities are abundant, but, although the outlook is good, the number of faculty research positions and industry jobs may not yet be sustainable.

Carving out a career in nanobiotechnology requires more than the cursory knowledge of multiple fields. Mastering at least two of the field's three core disciplines — molecular biology, chemistry and physics — is mandatory. Although PhD programmes are starting up that meet the needs of such interdisciplinary students, most current graduate applicants are still proficient in only one discipline.

In tune with the times: Andrew Pelling managed an unlikely marriage of nanotechnology, music and yeast.

Fortunately, many training programmes expose students to more than one area. At the Georgia Institute of Technology in Atlanta, for example, the nanocardiology fellow programme (one of three nanobiotech initiatives started at the institute in the past two years) requires students to work in nanotechnology development as well as in a cardiology lab. The biomedical-engineering school is a hotbed of nano-activity, boasting a new nanocancer centre as well as a nanomedicine centre run jointly with nearby Emory University (see 'Thinking small'). Other training programmes, such as the PhD programme at the Johns Hopkins Institute for NanoBioTechnology in Baltimore, Maryland, require students to be members of two advisers' research groups. Both programmes also include coursework in developing business plans, market assessment and securing funding (see *Nature* **435,** 124–125; 2005).

Big opportunities

Given the potential of nanosensors or molecular imaging tools to improve tumour detection, cancer is one of the hottest areas for research and graduate training opportunities. The US National Science Foundation and National Cancer Institute recently funded four centres for integrative graduate education and research traineeship programmes. The variety of university programmes indicates the dynamic nature of nanobiotechnology research: the University of New Mexico in Albuquerque specializes in integrative nanoscience and microsystems; New Jersey's Rutgers University focuses on nanopharmaceutical engineering and science; and the University of Washington in Seattle has a programme focused on building a workforce that can use nanoscale research platforms to understand and diagnose disease.

Student demand is also beginning to drive the development of undergraduate programmes in nanobiotechnology. Although Chad Mirkin, director of the International Institute for Nanotechnology

at Northwestern University in Evanston, Illinois, isn't convinced that undergraduate programmes are yet as meaningful as a solid foundation in the disciplines of physics, biology and chemistry, he can attest to the 'nano-effect'. Applications for graduate school at Northwestern went up dramatically after his institute formed in 2000. Increasing demand for training opportunities has also led to the formation of short courses such as the one on nanoelectronics at the European School on Nanosciences and Nanotechnologies in Grenoble, France. And the Georgia Institute of Technology offers a nanoscience and technology certificate programme to students of any undergraduate or graduate major. Only a few certificate-holders have so far graduated, but student participation is high — from a wide range of disciplines.

Given the early state of the field, skilled postdocs are in particularly high demand, says Jean-Marc Grognet, scientific director at both Nano2Life, a €15-million (US$19-million) network of excellence, and NanoBio, a Grenoble-based initiative focused on developing rapid, nano-sized laboratories on a chip.

The dearth of highly trained people has encouraged the relatively few existing companies to fund PhD projects. Flemming Besenbacher, director of the Interdisciplinary Nanoscience Centre at the University of Aarhus in Denmark, says one-third of the PhD projects at the university are financed by industries involved with the centre. And global electronics powerhouse Philips is investing heavily in molecular imaging as one of the main private funders of the public–private partnership initiative forming the Center for Translational Molecular Medicine located in Eindhoven, the Netherlands.

Market watch

Despite the many training opportunities, the job market remains uncertain. "It's too early to say whether nanobiotech efforts will translate into the industrial equivalent of the first biotech boom," says Michael Horton, a nanobiotechnologist at the London Centre for Nanotechnology. More and bigger grants are allowing for the number of positions in some faculty departments to be increased — although some of these posts are taken by internal academics realigning themselves in the field.

One area where there is likely to be a shortfall is in the number of skilled clinicians who can conduct the testing needed for nanobio-based diagnostics or therapeutics. Grognet believes that doctors who can discuss nanobiotechnology with physicists or biologists will be needed to prepare the development of clinical trials for new products.

Jean-Marc Grognet (top) and Chad Mirkin both see a high demand for skills in nanobiotechnology.

Businesses want students who can take the initiative — especially as formal nanobiotechnology positions at existing companies tend to be relatively limited. Nanosphere, a nano life-sciences start-up in Northbrook, Illinois, is recruiting roughly 10 people to bring its total number of employees to 100. The firm's chief executive, Bill Moffitt, says there is ample talent available but notes that it is hard to find people willing to put in the long hours and assume the high risks that come with working for a smaller company.

Invitrogen, an established life-sciences company in Carlsbad, California, with thousands of employees, plans to add just ten nanobiotechnology specialists. In an effort to recruit the top European talent while avoiding the difficulties of getting US visas, Invitrogen is also opening a biotechnology manufacturing facility, with a nanobiotech component, in Glasgow, UK, in early 2007. The company's strategy includes funding for internship positions.

Mark Morrison, scientific manager of the UK Institute for Nanotechnology in Stirling, points out that few companies are working in nanobiotechnology in Europe, but he expects to see more in the near future. Indeed, Europe has only half as many companies as the United States, but there are more than 150 small companies worldwide pursuing nanobiotechnology/nanomedicine products.

Boom or bust?

But until nanobiotechnology products can demonstrate success in clinical trials and are subsequently embraced by the marketplace, the future of the field — and the estimates that it will create thousands of jobs — remains uncertain. The area is now at a stage akin to biotech companies before the completion of the draft human genome in 2001. Companies related to genomics then received disproportionate media attention and high stockmarket valuations. But when few genomics-related products materialized, the biotech stockmarket bubble burst.

As a result of this lesson from history, the larger pharmaceutical companies are hedging their bets — letting the smaller companies take the risks, while only dabbling in the field. GlaxoSmithKline, for example, is not currently recruiting for nanobiotechnology-specific talent. Nevertheless, Denny Van Liew, senior director of strategic management for Pfizer Global Research and Development, hints that Pfizer may get more active sooner rather than later — particularly as it forges collaborative relationships with a number of universities, notably the University of Michigan in Ann Arbor and the Massachusetts Institute of Technology in Cambridge.

The potential that nanobiotechnology has in drug delivery, diagnostics and therapeutics will continue to engage the interest, if not involvement, of the large companies. In the near term, global investment in nanobiotechnology should give large companies plenty of projects to follow. Young scientists working in the field can benefit from this scrutiny — once they demonstrate results that have potential applications. "At the end of the day, people are looking for creative minds," says Pelling. For now, at least, Pelling is in a class of his own — nanobiotechnologist by day, cell jockey by night. ■

Virginia Gewin is a freelance writer in Portland, Oregon.

THINKING SMALL

As part of its effort to speed scientific discoveries from the bench to the bedside, the US National Institutes of Health recently completed its nanomedicine initiative — a network of eight national nanomedicine-development centres. The Georgia Institute of Technology in Atlanta — along with Purdue University in Lafayette, Indiana; the University of California, Los Angeles; and the Lawrence Berkeley National Laboratory — join four centres funded last year. The initiative will fund research and training efforts using an engineering approach to improve understanding of nanoscale molecular complexes that should be key to the development of diagnosis and treatment strategies. **V.G.**

http://nihroadmap.nih.gov/nanomedicine/index.asp