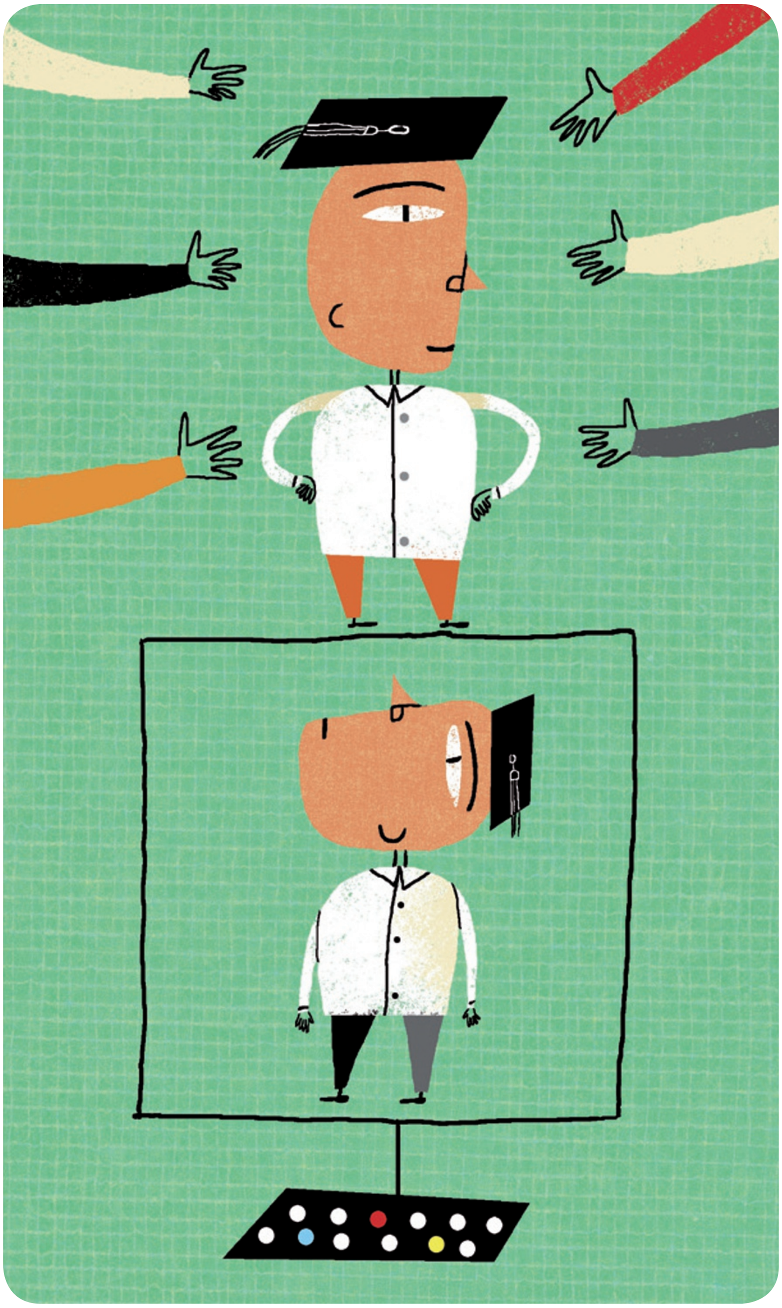

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EDUCATION

Outside the box

An industrial doctorate could help European students to break out of academia, but applied science is not for everyone.

BY QUIRIN SCHIERMEIER

Christian Hove Rasmussen isn't worried about getting a job. He is a PhD student at the Technical University of Denmark in Lyngby, but he is also an employee of Novo Nordisk, a pharmaceutical company based in Bagsværd, where he is doing doctoral research on the biological mechanisms that govern the absorption of diabetes therapies, such as insulin, in the fat layer beneath the skin. His fixed-term contract expires in 2013, but Rasmussen is optimistic that his work experience will help him to secure a permanent position in industry.

"I'm doing quite basic science, but it is target-oriented and I have to think about how it can be translated into medicine," he says. "I think I can achieve a lot here." Rasmussen's research — like that of around 60 other PhD candidates at Novo Nordisk — is funded by the Danish Industrial PhD Programme, a scheme set up by the Danish Agency for Science, Technology and Innovation (DASTI) in the 1970s. Last year, DASTI approved 116 industrial PhD projects, each funded by up to 882,000 Danish kroner (US$156,000). The host company gets a wage subsidy of 14,500 kroner per month for three years, and the university gets up to 360,000 kroner to last for the duration of the project.

Industrial PhD programmes are starting across Europe. Some are structured, and include university coursework components. Others are more informal. In all cases, the commercial and industrial aspects of the research are overseen by company experts who take part in PhD supervision. If all goes well, the benefits are mutual: doctoral students develop an in-depth understanding of business, which facilitates employment; and their skills and discoveries help the company. But students must be willing to engage in applied research that conforms to industry needs.

INDUSTRIAL EDUCATION

Students have long interacted with industry outside 'institutionalized' PhD schemes, says Lidia Borrell-Damian, head of research and innovation at the European University Association in Brussels. "It is not uncommon that during some point of a PhD a company is involved, in particular in science, technology, engineering and economics." Although explicit co-mentoring and co-funding have been available in the United States for about 60 years, they are only now becoming widespread and accepted in Europe.

In the United Kingdom, for example,

the Engineering and Physical Sciences Research Council (EPSRC) runs 26 industrial doctorate centres, each of which recruits a dozen or so students from different backgrounds each year. In addition, the EPSRC's industrial CASE programme provides support for individual PhD projects arranged between a company and an academic partner.

In France, around 10,000 science and engineering graduates have completed a PhD under the Industrial Arrangements for Training Through Research (CIFRE) scheme, funded by the National Association for Technical Research since 1981. The scheme is aimed mainly at students from the École Polytechnique near Paris, and companies post approved proposals on the university's website. Interested students can contact industrial partners to negotiate details and plan their dissertations.

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Christian Hove Rasmussen

The European Commission (EC) last year launched a €20-million (US$26-million) industrial PhD initiative as part of its Marie Curie Actions funding programme, which promotes mobility among young scientists. Approximately 100 European Industrial Doctorates will be funded under the pilot scheme, and the initiative is to become a permanent part of the European Horizon 2020 research-funding framework from 2014. Companies in the European Union or associated countries can submit research proposals without a specific PhD candidate in mind, but must have a partner university in a different eligible nation.

The structures of initiatives differ. Often, candidates spend 50% of their time or less at the university, and the rest at the company. Students at the ESPRC's doctorate take university courses in cohorts, accounting for 25% of their PhDs, but do placements separately. For the CASE and EC programmes, students deal almost exclusively in company research, although they ultimately have to defend their theses at the university.

The match-making processes also vary. In Denmark, students first need to find a company and agree on a PhD project. Then they, along with their university advisers, submit applications to DASTI. In CIFRE and the EC scheme, companies submit PhD research proposals first, then recruit students. The EPSRC's doctorate centres recruit students — accepting about 1 in every 20 applicants — and guide the match-making. Candidates for an EPSRC engineering doctorate in biopharmaceutical process development at Newcastle University, UK, have teamed up with companies in Britain and abroad, including GlaxoSmithKline and AstraZeneca, both based in London; Unilever in Rotterdam, the Netherlands; Procter & Gamble in Cincinnati, Ohio; and Heineken in Amsterdam. Elaine Martin, a chemical engineer at Newcastle who oversees the programme, says that the scheme has proved so beneficial that many companies return to ask for fresh talent.

OPENING DOORS

Finding an industrial partner is often a challenge, says Jane Thomsen, head of DASTI's Industrial PhD Programme. "Students should have a very concrete research idea before they contact a company," she says. "Mere interest in some kind of collaboration is not enough." An internship or company placement often leads to a job or a more profound collaboration — Rasmussen, for example, did his master's research at Novo Nordisk before his PhD.

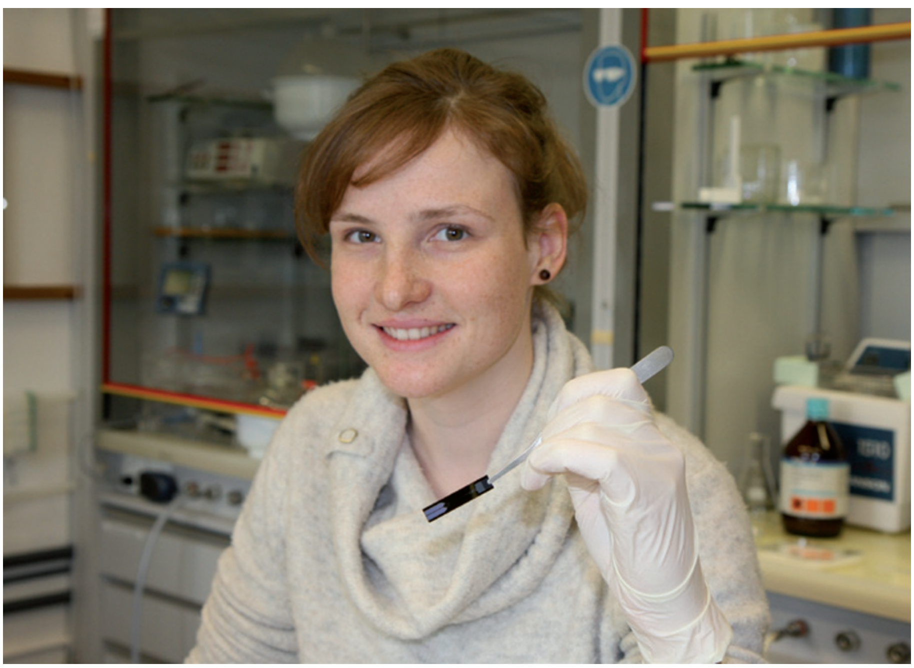
Similarly, Martina Hitzbleck became interested in industrial research after a three-month college internship with IBM's Almaden research centre in San Jose, California, in 2008. She learned that Emmanuel Delamarche, a scientist at IBM Zurich, was doing high-profile research on biosensor design — the subject of Hitzbleck's master's thesis — and she sent him her CV. After an interview and a presentation, Delamarche offered Hitzbleck a PhD project. He became her industrial supervisor, and Hitzbleck found an academic mentor at the Swiss Federal Institute of Technology in Zurich. She spends 90% of her time with IBM. "I get all the support here that I could dream of," she says. "Whenever I have a problem, there is an expert on whose door I can knock."

There are currently 36 PhD projects under way at IBM Zurich, mostly informal arrangements rather than part of a programme. Oliver Ottow, head of human resources and university relations at the lab, says that the match-making generally takes place at scientific conferences and graduate recruitment fairs, or through IBM's extended network of university contacts. "If students can convince us that their topics make a difference we'll find a home for them," he says. "We just want to make sure they're highly motivated and really very good." In principle, IBM gets research results and, possibly, a skilled future staff scientist. Students become familiar with applied, goal-oriented research, and learn about careers in industry, from patent law to media communication.

REASONABLE PRECAUTIONS

Students involved in informal collaborations should insist on a written agreement about the terms and conditions of the partnership, signed by themselves and all supervisors, says Borrell-Damian. "There is still a delicate balance between the respective interests of students, university supervisors and companies," she says. "A written agreement on all parties' rights and duties is therefore essential." Such agreements should specify topics and goals of the research, the required division of time and how intellectual-property rights will be assigned, she says. Company research departments will usually own the intellectual property, but students should insist on the right to publish their findings. In general, universities still administer final exams, even if students are full-time company employees.

There has been little research into the career paths of industrial PhD holders, but the few surveys that do exist suggest that graduates tend to stay in industry, usually in research. Even so,



IBM RESEARCH ZURICH

A college internship led Martina Hitzbleck to do a PhD at the IBM research centre in Zurich, Switzerland.

the door to academia is not necessarily closed (see *Nature* **466,** 402–403; 2010). Several former IBM researchers have moved on to become university faculty members, helped by the prestige of working in a high-profile industry lab.

Some academics fear that industrial PhD students may not acquire the full set of skills and knowledge required for independent scientific research in academia, ranging from methods to research ethics. "Academia and industry have fundamentally different roles and it is not helpful if they imitate each other," says Peter Blöchl, a theoretical physicist at Clausthal University of Technology in Germany. He worked for ten years at IBM's research laboratory in Ruschlikon, Switzerland, before moving to academia in 2000. Academia's mission is pre-competitive research and student education, he says. "Companies can tap into this knowledge base to develop innovative products, but I see little purpose for a PhD in industry." Joint projects, consultantships and sabbaticals are more productive, says Blöchl.

In general, students must be prepared for companies to tweak a research proposal to strengthen its commercial potential, says Thomsen. To avoid misunderstandings, they should make sure from the beginning that they are willing to accept such input. Early interviews with company researchers should help, but subsequent problems are best addressed with the help of the supervisor. In structured programmes, the funding agency will also review any complaints, and may intervene.

In the Danish scheme, says Thomsen, complaints are rare. If serious problems do arise — for example, if a host company goes bankrupt, or a PhD student is asked to do experiments or tasks unrelated to their project — the agency will try to mediate and, if necessary, demand the return of subsidies.

Concerns that industry is in it mainly for the cheap labour, and that projects lack scientific depth, are unfounded, says Martin. "All companies we're working with — even the manufacturing sites — have a serious interest in supporting genuine research."

But as industrial PhDs become more common, some do worry about exploitation of students and 'over-industrialization' of higher education. Eurodoc in Brussels, which lobbies for the rights of PhD candidates, warns that early-career research should be a free intellectual endeavour and not subject to the needs of business and industry. "Vanguard industrial PhD programmes are an opportunity to do what we all want to do — get work," says Greg DeCuir, a dramatic-arts PhD student at the University of Arts in Belgrade, and a member of Eurodoc's career-development group. "But we are not apprentices. If you feel that your scientific creativity is compromised, there should be a concern." ■

Quirin Schiermeier *is* Nature*'s Germany correspondent.*

TURNING POINT Christopher Wilson

Christopher Wilson, a physicist at Chalmers University of Technology in Gothenburg, Sweden, led one of Physics World*'s 2011 'breakthrough' experiments: he and his team proved that a vacuum, rather than being completely empty, contains detectable virtual particles. He explains his motivation for taking a working sabbatical at a biotechnology start-up in California.*

You did your undergraduate degree at the Massachusetts Institute of Technology (MIT) in Cambridge. How did this affect your career?

I was able to attend MIT after I won a US Naval Reserve Officers Training Corps scholarship, so I was expected to go into the navy afterwards. But I realized while I was at MIT, which is a very intense place, that I would rather do science. Between the second and third years of my degree, I notified the navy that I didn't want to join. They could have drafted me, but they allowed me the option of paying back the scholarship money, which I've been doing ever since.

How has your move to Chalmers influenced your research?

I worked at Yale University in New Haven, Connecticut, for two years and then moved to Chalmers to work on a quantum computing project, ostensibly for a year. I've now been there for seven years. In Sweden, the work dynamic is hierarchical, like a company. There is a top professor who has several professors at different levels working under him or her — and younger researchers work their way up. It's a good system if you have a good boss. It gave me more time and freedom to get this one big experiment to work than I would have had in the United States.

Describe your breakthrough experiment.

When I got to Chalmers in 2004, my team started work on superconducting circuits for quantum computing. Around 2007, we realized that the work could allow us to measure the virtual photons inside a vacuum. These virtual photons are generated and annihilated in pairs. About 40 years ago, it was suggested that a mirror moving near the speed of light could capture some of these photons. The effect had never been observed, because it is very hard to move a massive object that fast. We made an electronic 'mirror' that we could effectively move at one-quarter of the speed of light using magnetic fields. This allowed us to separate the pairs, stopping them from annihilating and turning them into real photons that we could observe (C. M. Wilson *et al. Nature* **479,** 376–379; 2011).

Could the media attention have a career benefit?

It certainly helps to put the paper in a certain light, especially for people outside our physics sub-field. For example, when applying for jobs, you are evaluated by a whole department. It can be difficult even for other types of physicists to evaluate the details of papers.

Why did you choose to take a sabbatical year at a start-up biotechnology company?

Last July, I was promoted to associate professor, which is tenured at Chalmers. In the US system, it is typical to take a sabbatical after getting tenure. Sweden doesn't follow the same timing, nor does the university pay academics to go on sabbatical, but I had planned to do it. I happened to see an ad on a job-posting site from a start-up company working on biomedical devices and proteomics. They needed someone skilled in algorithms and advanced statistical tools to analyse the enormous amount of data being generated about proteins, and I liked the people involved. It has turned out to be a good fit.

What kind of career impact do you expect the sabbatical to have?

I really wanted to do something to diversify my skills and develop some research lines that were completely my own — which can be a struggle in Europe's hierarchical system. I want to see if I can contribute algorithms to the field of proteomics. It would be pure hubris to think I could jump into biology, but I would like to find collaborators and see if I can develop a new aspect of my research. ■

INTERVIEW BY VIRGINIA GEWIN