

DENMARK:

MAKING GLOBAL CONNECTIONS

Denmark's Øresund bridge—connecting Copenhagen to southern Sweden—symbolizes the country's strengths in connecting basic and applied research, and academic and corporate interests. "Denmark has a well-educated population, a number of leading life science companies, and an international research environment," says Prime Minister **Lars Løkke Rasmussen**. Minister of Economic and Business Affairs, **Lene Espersen**, adds that Denmark encourages scientific entrepreneurship with "a skilled and flexible labor force, and government policy that nurtures new and emerging technologies and innovative companies." Both ministers say green technology is especially encouraged. According to the prime minister, "We have pursued an ambitious environmental and climate policy. This gives us an advantage now that these issues are getting global attention."

By Chris Tachibana



Lars Løkke Rasmussen

Connecting Bench and Bedside, Academics and Industry

Denmark has a long history of bringing basic research results to the marketplace. "We have a more than century-old tradition of generating successful pharmaceutical companies and conducting clinical trials, and a decade of experience in creating biotechnology companies," says **Ole Frijs-Madsen**, Director of Invest in Denmark (IDK). In the 1920s, in an early example of translational research, scientists and physicians partnered with the companies that became Novo Nordisk and LEO Pharma to develop insulin for clinical use. **Mads Krogsgaard Thomsen**, chief science officer of Novo Nordisk, says, "Denmark has traditionally been very strong in biomedical research. Some of the most cited clinical research in diabetes and metabolic disease comes from this part of the world." **Liselotte Højgaard**, professor in medicine and technology, University of Copenhagen agrees. "We have done translational research for a long time, we've just called it something else." Clinical studies are facilitated by "a strong emphasis on taking basic research results into patient studies," says Højgaard. "The population in Denmark knows that medical research improves patient treatment."

Based on these strengths, the Danish government launched a globalization strategy in 2006, outlined in the *Science* feature, "Denmark—Building on Tradition" ([dx.doi.org/10.1126/science.opms.r0600008](https://doi.org/10.1126/science.opms.r0600008)). That strategy aimed to increase funding for research and development to 3 percent of gross domestic product, with 1 percent from public sources. Prime Minister Løkke Rasmussen says the public expenditure goal will be met. "It is important to maintain focus, despite the global recession." According to IDK Director Frijs-Madsen, of the \$1.8

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billion allocated for the 2010-2012 globalization funds, \$1.4 billion is for advancing science and innovation. The strategy also planned to double the number of Ph.D. scholarships, and this appears to be on target. At Aarhus University, in Denmark's second largest city, **Erik Meineche Schmidt**, dean of natural sciences, says, "We have seen a major increase over the last three or four years in the number of Ph.D. students. We used to accept maybe 80 a year. Last year we admitted 130." About one-third are foreign students, many recruited from Eastern Europe. [continued »](#)

UPCOMING FEATURES

- Diversity 1: Women in Science—February 12
- Postdoc 1: Life Beyond the Bench—March 5
- Faculty 1: Lab Management—March 12

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— Lene Espersen

Corporate-Clinical-Academic Partnerships

For students and scientists seeking training in both academia and industry, Denmark offers excellent opportunities. The Danish Technical University, whose main campus is in Lyngby, north of Copenhagen, specializes in applied research and industry collaboration, covering areas from robotics to food science. A prime example of academic-corporate collaborations is the industrial Ph.D. scholarship, each of which is co-funded by the government and a company, and includes a mandatory business course. Students are trained in the “commercial aspects of research and development,” and create personal networks between companies and universities. In 2008, 119 industrial Ph.D. scholarships were granted, up from 50 in 2002, the first year of the program. Most are in biomedicine, engineering, and technology, but fields like agriculture and fisheries are also funded.

The biotechnology company Exiqon has hosted several industrial Ph.D. students, and all now have industry careers. According to CEO **Lars Kongsbak**, the students “learn the importance of delivering a product of value to customers, which you need to know to start a business.” They also gain communication experience. “An industry Ph.D. student sees the value of communicating, not only in academic papers and posters at scientific meetings, but also in sales brochures and public presentations.”

Another program that encourages academic-corporate collaborations is the Innovation Consortia program, started by the Danish government in 2007. A successful example is CureND, a consortium focused on finding drugs and diagnostics for Parkinson’s disease. It includes academic labs at Aarhus and Aalborg universities, and several companies, including Wyeth (now part of Pfizer). IDK’s Frijs-Madsen calls CureND “a targeted and innovative discovery research program, and an excellent public-private collaboration model.” **Daniel Otzen** is CureND’s director, and says the program works because “companies don’t want to just bankroll academic research but want genuine partnerships.” At CureND, “each partner has well-defined tasks. My lab was able to take the time to find the best conditions for

a high throughput screen that was subsequently turned into a genuine screening assay by Wyeth.”

Otzen exemplifies the easy flow between industry and academia. Between his Ph.D. and his postdoc in Lund, Sweden, he worked as a staff scientist at Novozymes, and says his work there became a major focus of his basic research at Aarhus University. “A stint in industry is great—I would strongly encourage it for everybody. It opens your mind for other working environments, and makes it easier to subsequently engage in transparent and mutually beneficial private-public collaborations.” This attitude has spurred biotechnology in Medicon Valley, as the network of biomedical research interests in Denmark and southern Sweden is known. In 2008, Ernst and Young ranked Denmark first out of 15 European countries in pipeline growth, with a 23 percent increase from 2006 to 2007 in the number of drug candidates in development.

Industry partnerships thrive at the Center for Sensory-Motor Interaction at Aalborg University in northern Denmark, a global leader in pain research. With a Center of Excellence grant from the Danish Research Foundation 15 years ago, Director **Lars Arendt-Nielsen** implemented a philosophy of “keeping key senior scientists as free as possible from administrative duties, so they can spend their energy on research projects.” Funding has increasingly focused on industrial partnerships, he says, so “over the last five years we have entered into more and more collaborations with industry,” and they now work with approximately 15 pharmaceutical companies.

Despite his success with industry partnerships, Arendt-Nielsen advises balance in research funding. “Without funding for basic science, we do not have new fundamental knowledge to move into applied research projects. Basic science and applied science must go hand in hand.” Aarhus University’s Otzen also warns about “a tendency of universities to bend over backwards to show they can apply their research.”

Thomas Mandrup-Poulsen, professor in medical research methodology, University of Copenhagen, conducts both basic and clinical diabetes research at the Hagedorn Research Institute and Steno Diabetes Center. He finds “growing interest in industry to engage with universities to address basic research problems, to enhance basic knowledge of disease mechanisms.” He suggests “a way to promote basic and translational research at the same time, is to have Ph.D. or postdoctoral fellowships that require collaboration between a basic research institute, a clinical institute, and industry.”

Support from the Private Sector

Basic and applied research receive strong support from private science foundations in Denmark. In late 2009, the Lundbeck Foundation announced a grant of \$6 million to establish the Lundbeck Foundation Nanomedicine Centre for Individualised Management of Tissue Damage and Regeneration, at Aarhus University. The goals are to apply expertise in biomedicine and nanotechnology to develop new methods in **continued »**

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diagnostic imaging, and tissue-specific protective and regenerative therapies. The Novo Nordisk Foundation (NNF) has been supporting research since 1926, and is a major force in Danish science. According to Director **Birgitte Nauntofte**, the NNF wants Denmark “to be recognized internationally as a hot spot for health science and biotech research, and to be associated

with quality, seriousness, innovation, openness, and creativity.” Nauntofte says the NNF has had an “extremely positive experience” funding large-scale initiatives, and “is likely to continue this strategy over the next couple of years.”

The NNF recently gave protein science a boost, with \$113 million for the NNF Center for Protein Research (CPR), which opened in June 2009. **Ulla Wewer**, dean of the Faculty of Health Sciences at the University of Copenhagen, where the CPR is housed, says they are “recruiting a strong team of international scientists to do basic research, knowing this will eventually strengthen industry.” The CPR will be building up its staff to 150, and will use systems biology, high throughput protein production, and proteomics to study therapeutically relevant proteins.

Another new initiative, co-funded by the NNF and the Danish Ministry of Science, Technology and Innovation, is the Danish Biobank at the Statens Serum Institute in Copenhagen. **Mads Melbye**, executive vice president of the institute, says they are cataloging approximately 15 million existing blood, tissue, and DNA samples from various pathology banks, and expect 200,000 new specimens annually. Physical samples will be coordinated with the wealth of data in Danish health registries, which include “birth characteristics of all newborns, hospital and outpatient diagnoses, a registry of prescribed medications, and a registry of all childhood vaccinations since 1990, which is unique worldwide,” says Melbye. Information can be tracked through generations, for inherited diseases, or by address, for infectious disease research. Citizens can opt out, but Melbye hopes that in two and a half years, aggregated population data, without personal information, will be available electronically to researchers around the world.

Bridges Across Borders

Julio Celis, director of the Institute of Cancer Biology for the Danish Cancer Society, is also distributing research information on an international scale. He is developing a network to link cancer experts in European Union countries, explaining: “Different countries have niches of expertise, so instead of duplicating them in all countries, it’s easier to connect them, so that we are faster in getting discoveries to the patient.” The realization that “cancer is complicated, and no single institute, country, or even continent would be able to deal with it,” led to the Stockholm Declaration, a commitment to join forces signed by the directors of 18 European cancer centers. Celis says the network will encourage mobility of expertise, students, and data, and create a “single-stop shop for industry discovery programs.” The network structure, and pilot projects on disease prevention and early detection, are in the planning stages.

Other globalization efforts are less virtual, aiming to bring scientists from other countries to Denmark. Nauntofte of the NNF says, “Denmark is a small country, so we have a limited pool of research talent. We must recruit highly competent foreign researchers, and our research groups must **continued »**

FEATURED PARTICIPANTS

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en.aau.dk

Lundbeck Foundation
www.lundbeckfonden.dk/en

Aarhus University
www.au.dk/en

Medicon Valley
www.mediconvalley.com

Center for Sensory-Motor Interaction
www.smi.auc.dk

Ministry of Science, Technology and Innovation
en.vtu.dk

CureND
www.neurocampus.au.dk/
menu55-en

Novo Nordisk Foundation Center for Protein Research
www.cpr.ku.dk

Danish Cancer Society
www.cancer.dk

Novo Nordisk Foundation
www.novonordiskfonden.dk/en/

Danish National Research Foundation
www.dg.dk

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www.novonordisk.com

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www.dtu.dk/English.aspx

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www.novozymes.com

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www.ssi.dk/sw379.asp

Hagedorn Research Institute
www.hagedorn.dk

Steno Diabetes Center
www.stenodiabetescenter.com

Industrial Ph.D program
en.fi.dk/research/industrial-phd-programme

University of Copenhagen
www.ku.dk/english

Invest in Denmark
www.investindk.com

Wyeth (Pfizer)
www.pfizer.com

LEO Pharmaceuticals
www.leo-pharma.com



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develop international collaborations.” Krogsgaard Thomsen of Novo Nordisk agrees, adding, “to be a little bit multicultural, a little bit diverse in your way of thinking, can only help creativity.” Aalborg University’s Arendt-Nielsen has always recruited from a global pool. “I founded my group 25 years ago with the policy from day one: interdisciplinarity and internationalization.” Half of his 80 researchers and 75 Ph.D. students are from outside the country.

According to Prime Minister Løkke Rasmussen, “It is important to attract scientists and specialists from other countries. We have made it easier in recent years to come to Denmark to work or study. The number of foreigners coming to work here has almost tripled since 2001, and the number of international students has doubled. This is a very positive development and a clear indication that Denmark is an attractive place to pursue a career.”



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— Ole Frijs-Madsen

Danish Strengths and Challenges

As Denmark looks to the future, several challenges must be met. Knowledge of English is widespread, and English is the official language of the Center for Sensory-Motor Interaction, and the corporate language of Novo Nordisk. However, the default language for many classes and meetings is Danish. Højgaard of the University of Copenhagen says, “When we train people to be bioengineers or doctors in Danish, it’s because, well, we’re Danish. But that’s an obstacle to having a truly international system. We have to acknowledge that English is the language of science, and develop a more bilingual system.”

Making improvements in postdoctoral training is another challenge. Danish students complete Master’s and Ph.D. projects in different laboratories, and their Ph.D. training includes a period abroad, but professorships do not require postdoctoral experience. Aarhus University’s Otzen says, “The idea here is that when you have a Ph.D, you are a fully fledged scientist. But it doesn’t matter if you’re going into academics or industry, you need to have a postdoc period,” which he compares to adolescence, “where you mature and find your feet.” Aalborg’s Arendt-Nielsen adds, “Over the last 10 years, a lot of money has gone into collaborative Ph.D. projects between universities and industry. It is time for Denmark to also focus on

postdoctoral education.” Mandrup-Poulsen of the University of Copenhagen advocates mandatory postdoctoral training to qualify for an assistant professorship. He also expresses “concerns about the mismatch between the number of postdoctoral positions relative to the pressure to educate ever more Ph.D.s,” and suggests transferring funds from Ph.D. programs to postdoctoral grants.

Inge Mærkedahl, director of the government’s Agency for Science, Technology and Innovation, recognizes that “increasing the enrollment of Ph.D. students also increases the need to fund more postdoctoral fellowships.” She said that in addition to annual postdoctoral funds from the Danish Council for Independent Research (DFF), a new source of support is the Sapere Aude program. “This comprehensive career program is being launched in 2010 by the DFF, with total funding of approximately \$72 million,” explains **Linn Hoff Jensen**, head of section at DFF. “In the first year, it expects to fund 45 post-docs and a minimum of 27 associate professors.” The program hopes “to enhance the international opportunities for excellent and experienced researchers, both male and female, creating role models to inspire younger researchers.”

One of Denmark’s strengths is its attractive work environment. **Meineche Schmidt** of Aarhus University says, “The Danish labor market is known for high employment security and flexibility,” with good government support during job transitions. “People are reasonably well paid, although the cost of living is also high.” The small size of Denmark, with 5.5 million people, is an advantage for networking. Krogsgaard Thomsen of Novo Nordisk says, “People may find it awkward to move here from a big country like the United States, but once they settle down they tend to like it.”

Denmark continues to be a leader in “epidemiology, clinical research, and basic research directed at understanding disease mechanisms,” according to Mandrup-Poulsen. Celis of the Danish Cancer Society adds, “The environment is especially good for translational research because of the high standards in clinics. And patients like to participate in clinical trials.” Another advantage to working in Denmark is 5-6 weeks of paid vacation, although Celis says, “Most of our scientists don’t take all the holidays!”

Danish institutions have a flat power structure, stemming from the Jante Law, a social principle that says no one is better than anyone else. The University of Copenhagen’s Højgaard says, “There is a straightforward, old Viking attitude that knowledge and competence count more than rank and title.” Aalborg University’s Arendt-Nielsen agrees, saying, “The only thing that counts is your scientific merits.” Combining the Jante Law with a natural pride in Denmark’s strengths, Højgaard states, “It’s difficult to brag about your own country, but we are doing well in research in Denmark.”

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