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WHY IS DANISH LIFE SCIENCE THRIVING?

A case study of the life science industry in Denmark

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Research and Innovation for Sustainable Growth.

Why is Danish life science thriving?

A case study of the life science industry in Denmark

by

Stina Gestrelius

Preface

In December 2006, VINNOVA was assigned by the Swedish government to conduct an international benchmarking of the Swedish sectorial innovation systems in pharmaceuticals, biotechnology and medical technology. Case studies and international comparisons of different countries are important in assessing and understanding the Swedish conditions for life science research and innovation. Therefore, VINNOVA commissioned Medicon Valley Alliance for the present report, comparing the situation and trends in Denmark with those in Sweden.

This study is based on data and information concerning policy, trends and performance in the Danish Life Science innovation system. In terms of industrial structure and size, the report is largely based on a forthcoming report which charts and categorises Danish companies in biotechnology, pharmaceuticals and medical technology for 2006 according to their type and size[1]. The same basis for categorisation was used as for the recent VINNOVA report on the Swedish life science industry[2]. A comparison has also been made with an earlier survey from 2003[3] of the Medicon Valley region's companies and employees.

The report is also based on published studies and information, including annual reports and governmental papers. In addition, representatives of governmental bodies, venture capital firms, and large and small life science companies have been asked about the character and importance of frame work conditions for this industry in Denmark. The interviewees have also commented on conclusions from the previously mentioned report and other studies referenced. We would like to express our gratitude to those who have freely shared their time, experience and views with us. Naturally they are not responsible for any misinterpretations or omissions in the text, which has been written in part from a Swedish perspective. The report was written by Stina Gestrelius, Medicon Valley Alliance. The Project Manager for the international benchmarking project is Anna Sandström, VINNOVA.

VINNOVA in September 2008

Göran Marklund
Director and Head, Strategy Development Division

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[1] Biotechnology, pharmaceuticals and medical technology in Denmark 2007 - National and regional cluster profiles, Gestrelius S., Sandström A. & Dolk T. (2008)
[2] Biotechnology, pharmaceuticals and medical technology in Sweden 2007 - National and regional cluster profiles. Bergqvist H., Sandström A. and Dolk T., VA 2007:16
[3] Complementary study to VINNOVA Analys VA 2005:02 concerning the Medicon Valley region, Gestrelius S. & Dolk T. (2005), http://www.vinnova.se/upload/EPiStorePDF/va-05-02-kompletteringsPM.pdf

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Summary

The life science industry, which in this study includes pharmaceuticals, nutraceuticals, medical technology, industrial biotechnology and agricultural biotechnology, is big business in Denmark. Jointly, these industries had a turnover of nearly DKK 100 billion in 2006 which was equivalent to over 5% of the Danish gross domestic product. The aim of the present study has been to look for structures and factors that promoted this successful development.

The biotech industry has deep roots in food production pre-dating 1900. Industrial development of pharmaceuticals started a hundred years ago, as did the successful medical technology speciality, audiology and hearing aids. Nearly all the big companies are controlled by foundations, e.g. Novo Nordisk, Novozymes, Leo Pharma, H Lundbeck, Carlsberg and Oticon. This type of ownership has secured their continued growth in Denmark. The wealthy foundations also invest in R&D and innovation, and several companies have established their own incubators for developing new inventions into enterprises.

Thus, the mere existence of many large biotech, pharma and medical technology companies in a small country was favourable for life science innovation. Furthermore, the public research and innovation system also prioritised health and biotechnology. Industry, universities and hospital regions then joined forces to establish a recognised cluster, Medicon Valley, for regional collaboration around Öresund as well as international branding.

In 2006, Denmark had 270 life science companies aiming for an international market and with R&D and/or production in the country. Over half of the companies were working with pharmaceuticals or diagnostics, 25% with medical technology and about 20% with other types of biotechnology, especially industrial and food/agricultural biotechnology.

These companies jointly employed about 40,000 full-time equivalents (about 1.5% of the total workforce). The Danish part of Medicon Valley, with Copenhagen and Sjaelland, had the vast majority of the firms and about 37,000 of the employees. A comparison to an earlier study of Medicon Valley indicated a job increase of nearly 10% between 2003 and 2006. The new employees were found in both large and small companies, including new start-ups.

Over half of the companies were established in Denmark between 1997 and 2006, and had a higher average growth rate, nearly 30%. Most of these

companies were active within biopharmaceuticals. The mean size in terms of employees was higher than in many other European countries, and the high average number of biotech products in clinical trials was important for the very positive valuation by venture capital firms. In 2006, the Danish biotech companies collected DKK 1 billion in venture capital, taking fourth place in Europe after France, the UK and Germany.

Approximately half of the young companies are spin-outs from industry, and the other half are start-ups from universities and university hospitals. The high quality of research in Denmark, as demonstrated via bibliometry and high ranking of the universities, appears to pay off when matched with experienced industry managers. From a Swedish perspective, the large number of spin-outs from industry is surprising, especially since they originate not only from large companies but also from growing small and medium-sized enterprises (SMEs) such as Neurosearch (from 1989) and Nordic Bioscience (from 2001).

It is also very interesting to note that some of the successful spin-outs have been based on intellectual property rights acquired from the US. The commercialisation in Denmark was made possible by professional managers, international boards and venture capital firms syndicating internationally. Other important success factors for all the new companies include niche strategies and favourable business conditions, including employee flexicurity and a generous attitude to foreign specialists. Unfortunately, Denmark (like Sweden) still lacks tax incentives for young biotech companies of the type that exist in several other European countries.

Many administrative changes regarding public support for research and innovation, including the merger of universities and new strategic programmes for research and research collaborations (via the Advanced Technology Foundation for example), are too recent to have had an impact on the biotech industry during 2006. Even the impact of the Act on Inventions at Public Research Institutions of 2000 was not easily traced, as most of the growth companies are developing technologies invented before this law was enacted. These initiatives are expected to be important to Denmark’s continued globalisation strategy.

1 Introduction

Hvorfor går det godt i dansk biotek? means *Why is Danish biotech thriving?* This intriguing question was the title of a recent article in Danish media (Valentin et al, 2007:4). The question also explains in a nutshell what the present report is intended to give – i.e. an idea about the structure and factors that shaped or promoted the development of the life science industry in Denmark. The report was commissioned from Medicon Valley Alliance by VINNOVA as a means of evaluating success factors that might be of interest to implement in Sweden.

The report utilises three types of sources:

(1) Published studies and information, including annual reports and governmental papers;

(2) A new mapping of life science companies (biotechnology, pharmaceuticals and medical technology) in terms of their type and size measured by employees in Denmark in 2006.

Companies with research and/or production (but not marketing and sales only) were grouped into 22 different business segments and seven activity categories with the same criteria as used for the recent report on life science in Sweden (VINNOVA 2007). A comparison has also been made with an earlier mapping for 2003[4] of companies and employees in the Medicon Valley region.

(3) A series of interviews conducted during the spring of 2008.

A few representatives of governmental bodies, venture capital firms, and large and small life science companies were asked about the impact of frame conditions for this industry in Denmark, with emphasis on bottlenecks and trends. The interviewees were also asked to comment on some conclusions from the mapping and reports which have been referenced, but naturally they are not responsible for any misinterpretations or omissions in the text, which has been written in part from a Swedish perspective.

[4] Complementary study to VINNOVA Analys VA 2005:02 concerning the Medicon Valley region, Gestrelius S. & Dolk T. (2005), http://www.vinnova.se/upload/EPiStorePDF/va-05-02-kompletteringsPM.pdf

2 The life science industry before 1989

Historically, life science in Denmark focused on food and fermentation and on export business. In a Nordic comparison, Denmark is the country that has bred business competence as a part of the innovation culture, very much due to the direct sales of consumer products (Nordic Innovation Centre 2004). Well known giants from the 1870s such as Carlsberg and Danisco have developed much wider research areas than beer or sugar. For the pharmaceutical industry companies like, Leo Pharma, Novo Nordisk and Lundbeck, which date to the early 1900s, apart from having their headquarters and main research units in Copenhagen, also have most of their production there as well. Denmark also has a large medtech industry, based on user-driven innovation. An important speciality is the technical development and design of advanced hearing aids, but the disposable devices segment is even larger.

Many of the big companies are locked in foundations, which have secured their independence and stability. These foundations are also known for providing grants and donations to public research and infrastructure.

This chapter will describe the “old” life science industry and how it has promoted growth of new companies in recent decades.

2.1 Food/agricultural and industrial biotech

The Carlsberg Research Center was founded in 1875 to develop the scientific understanding of the malting, brewing and fermentation processes. A century later, it instigated its own bioincubator and has spun out biotech companies such as Carlbiotech in 1980 (enzymatic peptide synthesis, later Peptech/Australia), Combio in 2000 (later merged with Arpida (Switzerland)), Versamatrix in 2004 (acquired by Novo Nordisk 2007) and 2CureX in 2006. The Carlsberg Foundation is the majority owner of Carlsberg A/S, and supports culture and science through internal units as well as grants. A recent example is the funding of microRNA research at the University of Copenhagen.

Until recently, Danisco was known as a major sugar producer, but sugar is now a separate business about to be divested, and Danisco has developed into a corporation producing food ingredients and industrial biotech, especially after the acquisition of US-based Genencor in 2005. The Innovation Center in Århus is now also the centre of Danisco’s enzyme

research in Denmark. Danisco Venture (active 2001-2007) had a capital budget of DKK 500 million and invested in start-up companies Jurag and Poalis, and also in DTU Innovation.

Chr. Hansen started production of enzymes and colourings for cheese manufacture back in the 1870s, and is now another major player in food ingredients, enzymes and probiotics. The private equity firm PAI Partners has owned the company since 2005. Chr. Hansen recently acquired the Swedish bioproduction company Medifarm, and is to open the world's largest plant for dairy culture near Copenhagen in 2008. The investment is DKK 300 million and 50 new employees will be needed.

> *"After thorough consideration we decided to build in Denmark, where we already have a strong and advanced logistics platform. Furthermore, the educational level is high and our operation is mainly knowledge-focused as opposed to manpower-focused",*

concluded Lars Frederiksen, CEO. (Press release, Oct 2007).

Novozymes, the world's largest enzyme producer, started as a division of Novo Nordisk, but became a separate entity in 2000, and has continued to grow rapidly throughout the world as well as in the Copenhagen area. Bioethanol production from non-edible biomass is an important new field of enzyme development. Other research areas include biopolymers and biopharmaceutical ingredients. The company's research units in Denmark, the UK, the US and Japan are collaborating globally with universities and industrial partners, and the company evaluates projects and SMEs for acquisitions. Novozymes bought Biogaia Fermentation in Lund in 2002 and has since expanded its biopharma capacity, having recently moved production from Australia to Lund. Novozymes had the highest number of corporate biotechnology patent applications in Europe during 2002-2006 and was in fifth place worldwide (Marks & Clerk 2007). It is therefore unsurprising that some internal projects are potential spin-outs.

Taken together, these four biotech companies have nearly 5,000 employees in Denmark with about half of that number in R&D. This is an overall increase from 2003.

Table 1: Old biotech companies in Denmark.

Company	Established	Employees (FTE) in Denmark 2006
Carlsberg *Research Centre*	1875	175
Danisco (incorporated Genencor in 2005)	1872	1450 (sugar division not included)
Novozymes (split from Novo Nordisk in 2000)	1939	2200
Chr Hansen	1874	850
ALL		About 4700

2.2 Pharmaceuticals, including biopharmaceuticals

Leo Pharma is the oldest pharmaceutical company in Denmark and celebrates its first centenary in 2008. The company is renowned for being the first outside the UK and the US to produce penicillin in 1943. Today, Leo concentrates on psoriasis and other skin diseases and is wholly owned by the Leo Foundation. Leo Incubator was initiated in 2001 to support early projects and start-ups in the Öresund region, such as QSI Pharma which was based on research from DTU (the Technical University of Denmark).

For 50 years, *H. Lundbeck* has concentrated on psychiatric and neurological disorders based on in-house research. Now in the US as well as Denmark, the company saw its best ever results in 2007. The Lundbeck Foundation (est. 1954) has owned 70% of Lundbeck A/S shares since the company was listed on the Copenhagen Stock Exchange in 1999. It is also the majority owner of *ALK-Abelló* (listed in 2005 when Chr. Hansen was sold to PAI Partners), a rapidly growing pharmaceutical company which has had a tablet for grass allergy on the market since 2006. The Lundbeck Foundation supports research in Denmark through grants and donations. In 2007, these amounted to almost DKK 300 million. *Life Cycle Pharma* was spun out from Lundbeck in 2002 and made an IPO in 2006. The company develops proprietary formulations that are bioequivalent to existing approved drugs.

Novo and Nordisk Insulin, two Danish giants in insulin and diabetes therapy, merged in 1989 and have since dominated the world market. Each founded diabetes hospitals in Copenhagen back in the 1930s, and both Steno and Hagedorn are now important research centres. *Novo Nordisk* is the largest life science company in Denmark and has a direct impact on the Danish economy. In 2006, its financial contribution was 2.2% of the total GDP increase, according to the company's annual report. In 2007, its net

profit increased by a further 25% (adjusted for income from the divestment of DAKO, see below). In May 2008, Novo Nordisk filed for regulatory approval in the US and Europe of Liraglutide, a once-daily human GLP-1 analogue for the treatment of type 2 diabetes. This product is expected to make sales in excess of USD 1 billion in a year. During 2007, the company opened a new DKK 500 million pilot plant north of Copenhagen for the manufacture of investigational compounds for clinical trials, not only within existing biotherapeutical areas but also for cancer and inflammatory diseases such as rheumatoid arthritis and psoriasis. Furthermore, in 2007 Novo Nordisk decided to discontinue R&D related to small molecules, and donated its small molecule compound library (325,000 different chemical structures) to the National Centre for Drug Screening in Shanghai. This centre collaborates with the Chinese Academy of Sciences and WHO to target the infectious tropical diseases which frequently occur in poorer countries.

The old Novo Foundation was transformed into the Novo Nordisk Foundation at the time of the merger with Nordisk. As already mentioned, Novozymes was spun out as a separate sister company in 2000 and the Novo Nordisk Foundation now owns Novo Nordisk, Novozymes and the investment company Novo A/S. Novo Nordisk sold its diagnostics company to *DAKO* in the early 90s and thereafter owned nearly a third of DAKO until it was acquired by EQT in 2007. Recently, Novo A/S proposed that the Novo Nordisk Foundation should acquire another big company of the size of Novo Nordisk and Novozymes so as to gain a "third leg" in the biotech field (Børsen, 23 April 2008).

Novo's importance to the development of new biotech and pharma companies cannot be overestimated. With some 10,000 Copenhagen-based employees and a research budget of DKK 7 billion, there are contacts and collaborations throughout Medicon Valley, demonstrated by for example frequent co-publications with the Universities of Copenhagen and Lund (Wichmann Matthiessen et al, 2007). Many researchers have learnt the commercial thinking at Novo Nordisk and gone on to become entrepreneurs, starting or contributing to the development of new companies. Interestingly, very few of these start-ups are within Novo Nordisk's core area of diabetes. Wichmann Matthiessen et al concluded that

> *"Novo is a major agent in the knowledge fabric of Greater Copenhagen and is the key to the pharma-medico cluster development"*.

The Novo Nordisk Foundation works almost like a public R&D financier and instigates many different means of supporting research and innovation in Denmark, including professorships, 70 financed or co-financed PhDs and

postdocs, senior research scholarships for repatriation of Danish researchers from abroad, one-year master's scholarships for students at Medicon Valley universities, pre-seed and seed money for new companies, etc.

The Novo Nordisk Foundation Centre for Protein Research is currently being established at the University of Copenhagen, thanks to a donation in 2007 of DKK 600 million. The Director of the centre, a Swede, is building up a group of about 100 researchers for basic and applied discovery research on medically relevant human proteins.

Nycomed has Danish roots, but moved its headquarters to Zürich following a merger with Altana Pharma AG in 2007. *Ferring Pharmaceuticals* was a Swedish company when it first established a production unit in Copenhagen and subsequently its main offices and research unit. Its is now headquartered in Saint-Prex, Switzerland, and the International Development Centre is in Copenhagen.

Table 2: Largest pharmaceutical companies in Denmark.

Company	Established	Employees (FTE) in Denmark 2006
LEO Pharma	1908	1,200
Lundbeck	1915	2,000
Novo Nordisk A/S excl. NNIT & NNE Pharmaplan	1920's (1989)	10,000
Nycomed (as DAK)	1922	700
Ferring Pharmaceuticals	1956/1999	400
ALK-Abelló	1923/1992	500
ALL		~15,000

Compared to the previously described "big biotech", the pharmaceutical firms have three times as many employees. Ferring and Nycomed have moved their HQ but kept R&D or R&D + production in Denmark. ALK-Abelló is rapidly growing and the overall net change from 2003 to 2006 is a clear increase in number of employees in the largest pharmaceutical companies.

In 2006, total Danish exports of pharmaceuticals amounted to DKK 40 billion, according to the Danish Pharmaceutical Industries Association (Lif). This was about three times more than in 1995.

2.3 Medical Technology

The medical technology industry started in Denmark in early 1900s with William Demant (*Oticon*) producing hearing aids. Audiometry and advanced hearing aids are still Danish specialities, with Oticon, GN ReSound, GN Otometrics, Widex, Interacoustics and Sonion amongst others developing and producing equipment or components. Sonion also has a division for drug delivery and minimally invasive surgical devices. One programme, recently supported by Hoejteknologifonden (the National Advanced Technology Foundation), aims at developing electroporation for patients with brain cancer.

The Danish government opened up the local market by making hearing tests and hearing aids free of charge from 1953. In 2003, the Centre for Applied Hearing Research (CAHR) was established at the Technical University of Denmark. The centre is supported by Oticon, Widex and GN Resound and their foundations, and its aim is to promote research and education in the field of acoustic communication, including speech perception and diagnosis of auditory function in clinical and technical audiology.

The audiology cluster has over 3,000 employees in Denmark, many of whom are in R&D as manufacture made an early move to Eastern Europe or Asia. The companies jointly account for 45% of the world market (McKinsey 2007). According to Lindgaard Christensen et al, 2008, this success was based on a unique combination of a welfare state emphasising social cohesion and a mode of innovation based on interactive learning and international trade.

Table 3: Largest companies in hearing aids incl. components and audiology measurements.

Company	Established	Employees (FTE) in Denmark 2006
Oticon (W Demant)	1904	1,300
GN Resound (GN Store Nord)	1943	400
GN Otometrics (GN Store Nord)	1960	200
Widex	1956	700
Interacoustics (W Demant)	1967	150
Sonion	1974	250
ALL		~3,000

Radiometer's roots go back to the 1930s when it started developing measuring instruments for the radio industry. However, today Radiometer is the market leader in blood gas analysis and is owned by the Danaher Corporation (USA).

Disposable devices, including wound-healing products, have grown into the largest group in medical technology in Denmark. *Coloplast* from 1957 is a perfect example of a company based on user-driven innovation from the healthcare sector. The company is active in the fields of ostomy, urology and continence, and wound and skin care. Coloplast has 2,400 Danish employees of a total of 7,500 and production units in Denmark, Hungary, the US and China. The challenge, according to the company's annual report is to grow the US market share. During 2006, Coloplast acquired Mentor, Inc. in Minneapolis, and more acquisitions are expected (Business.dk, 2008). Coloplast has recently established an incubator function and invested in Interface Biotech A/S in 2007.

Established in 1937, *Ambu* is now a multinational company with HQ and development in Copenhagen and manufacturing units primarily in China and Malaysia. Medicotest was acquired in 2001. This was a Danish start-up company from 1971, which developed disposable electrodes in collaboration with the University of Copenhagen. *Unomedical* started as PharmaPlast, and has grown via a series of acquisitions. The company is owned by Nordic Capital (private equity fund) and in 2006 moved a substantial part of its manufacturing to Slovakia.

A European centre for development and production of medical devices for interventional radiology, cardiology, critical care and vascular surgery, was established in the 1970s south of Copenhagen by *Cook Medical*. This was an early example of an international life science company moving to Denmark with both development and production.

Table 4: Largest companies in medical devices and analysis instruments (excl audiology).

Company	Established	Employees (FTE) in Denmark 2006
Radiometer	1935	950
Ambu	1937	350
Coloplast	1957	2400
Unomedical (first Pharma Plast, later Maersk Medical)	1964	750
William Cook Europe	1969	600
ALL		~5000

Thus the audiology cluster and the five largest companies in medical devices employ over 8,000 people in Denmark. The Danish industry organisation Medicoindustrien reported (2007) a total of 18,000 employees in Danish medtech industry in 2006, with most of the 220 enterprises (many in marketing & sales) having fewer than 50 employees. The total turnover in Denmark was about DKK 17 billion and global turnover about DKK 40 billion.

3 Initiatives to strengthen innovation

3.1 Attraction policies/Medicon Valley

The mere existence of many large biotech, pharma and medical technology companies in a small country like Denmark is of course favourable for life science innovation. However, these companies have also joined forces to establish a recognised cluster and cluster organisation.

The Medicon Valley concept was invented in the mid-1990s and developed through the creation of MVA, the Medicon Valley Academy (now Alliance) in 1997. The universities of Lund and Copenhagen were the initial drivers, backed by a group of public and large private organisations including NovoNordisk, Lundbeck and Coloplast plus AstraZeneca and Gambro from the Swedish side. The name Medicon Valley for the life science cluster around Öresund was, and is, promoted by the regions of Copenhagen, Sjaelland and Skåne, as well as by Copenhagen Capacity and other inward investment organisations.

At its 10th anniversary in 2007, the non-profit organisation MVA had 270 paying members, of which about 240 were private companies. Its very first activity in 1997 was to map the region and produce a logo chart and website. Networking across Öresund accelerated when the bridge between Copenhagen and Malmö opened in 2000, and a number of collaborative programmes started. Since then, MVA has organised PhD and postdoc programmes (with regional and private funding), conferences, information meetings for start-up companies, matchmaking events and many other activities. The ambition to make Medicon Valley one of the most attractive bioregions in Europe was realised and a new vision of Medicon Valley as a global node for life science was launched via the Life Science Ambassador programme in 2007. The exchange of personnel has started with Japan and will continue during 2008 with Canada and South Korea. The new global initiative is matching the demand for people, patients and partners now being experienced by large and small enterprises in Medicon Valley.

The Danish and Swedish sides of Öresund both use the Medicon Valley website for inward investment information, as evidenced in Table 5.

Table 5: Inward investment information[5].

Medicon Valley (Danish side) offers a range of features for R&D-oriented companies, e.g.

- Low corporation tax of 25%.
- R&D expenses are normally fully tax deductible. Companies can choose to deduct either the full amount for the year in which the expenses arose, or amortisation may be apportioned in equal instalments over a period including the year the expenses arose and the four subsequent years. Typically, the deductible expenses relate to salaries, raw materials, and premises. However, expenses related to R&D carried out by other organisations and expenses related to acquiring intellectual property rights are also deductible. Capital expenditure related to machinery and equipment used exclusively for research and development purposes are fully deductible in the year the equipment is acquired.
- Attractive tax schemes for foreign researchers and other key personnel.
- Grants to employ PhD students.

3.2 General conditions

General conditions favouring establishment in Denmark include the low degree of bureaucracy, a modern e-society, a well-educated, English-speaking population, the employee flexicurity rules, and possibly also the supply of venture capital. Ørestad City, near Copenhagen Airport, offers many new opportunities for office and living space with its excellent infrastructure into central Copenhagen by train and Metro and across Öresund by the bridge to Malmö.

Several reports have ranked Denmark as one of the best countries in Europe for doing business. The World Bank (2008) recently gave Denmark fifth place globally after Singapore, New Zealand, the US and Hong Kong. According to OECD, the Danes are also the most positive towards globalisation. They refer to effects of the flexicurity system, which provides unemployment benefit for everyone regardless of whether they are fired or leave a job voluntarily.

Examples of establishments in Medicon Valley from the US, Japan and Europe include Acadia Pharmaceuticals (1997, R&D), Genzyme (2002, R&D), BiogenIdec (2003, Production), Astellas Pharma Nordic (2004, marketing and sales), UCB Nordic (2005, marketing and sales), Xendo Pharma Services (2006, CRO) and Oncotech (2007, then acquired by

[5] www.mediconvalley.com

Exiqon A/S). *Acadia* later moved within Medicon Valley to Malmö (Sweden), while *BiogenIdec* has expanded its investments at Hillerød north of Copenhagen. The new packaging unit and quality control laboratory were inaugurated in 2007, and a large bioproduction unit is under construction, requiring a doubling of the staff to 400 by 2009.

Maxygen was established in Denmark after acquisition of Profound Pharma in 2001. The company decided to move its Danish research (70 people) to the US in 2008, when the projects advanced from preclinical to clinical research phases. High costs in Denmark combined with a weaker dollar were also given as an explanation.

Having used up its three years on favourable tax schemes, the small Copenhagen-based company *Glycom* with its many international researchers, is threatening to move to Hungary. Recently, the Danish government proposed an alternative scheme, whereby income tax could be reduced to 33% for five years instead of 25% for three years. It should be noted that the requirement for being considered a foreign expert in Denmark is a salary above DKK 60,100 per month or R&D work as defined by OECD. This is different from Sweden, where a separate evaluation of specialist status is required in order to obtain a three-year tax reduction.

The high level of Danish income tax was mentioned in all interviews as an obstacle to keeping international specialists. Social security is largely paid by the employee and not by the employer as in Sweden. However, if the total taxation of work income is compared, then Sweden's tax is over 5% higher than Denmark's (Lodin 2008). After his re-election in November 2007, Danish Prime Minister Anders Fogh Rasmussen opened parliament by underlining the need for tax reform *"to attract an overseas workforce"*.

Corporation tax is 25%, which is an average in OECD but lower than in Sweden. The tax rule allowing companies to carry their tax losses forward indefinitely for offsetting against future profits is mentioned as a positive governmental initiative. Despite proposals from Medicon Valley Alliance (2004), tax incentives for young innovative companies of the kind found in several other European countries do not exist.

3.3 Venture capital

The number of Danish VC funds investing in life science increased from three in 1999 to over 10 in 2006, with a total of about DKK 9 billion in the funds, equivalent to over half of all invested venture capital in Denmark.

Several of the companies that are growing today, such as 7TM Pharma, Symphogen and NsGene, started with the kind of soft loans that are no loner given by Vaekstfonden, the Danish government's investment fund. The

many start-ups around 2000 were lucky to be backed by the new VC funds when the emphasis was on start-up/spin-out companies. Many of these were also helped by Vaekstfonden through the difficult years of 2003-2004. Investors switched focus to the existing portfolio and in 2006 only about 10% of the capital went into new start-ups (Vaekstfonden 2007).

Vaekstfonden was established in 1992 with DKK 2 billion from the government. In 2001, the strategy was changed from subsidised project loans to investing seed capital in companies at a stage deemed too immature and risky for ordinary venture capital. Some investments are direct but many are indirect, via capital put into (19) venture funds. According to a new report, about one third of the capital invested in 2007 was in companies supported by Innovation Environments (cf. Section 3.6, Vaekstfonden 2008). The portfolio consists of over 200 companies. Five of the oldest from Innovation Environments have raised nearly DKK 700 million from other investors. Not unexpectedly, four are in life science (Chempaq, Action Pharma, M2Medical and Evolva). Amongst the exits, which resulted in DKK 100 million or more per company, two out of four were from life science (Survac, Neurodan) and the third may have an interesting technology for hearing aids (AudioAsics). Survac was sold to Merck (Germany) in 2004, Neurodan in 2005 to Otto Bock (Germany), and AudioAsics to AnalogDevices (USA) in 2006.

Syndication with international investors has become important, and nearly half the capital raised in 2006 came from abroad. Alta Partners, Atlas Venture, the German biotech fund, Global Life Science Ventures, Index Ventures and the Dutch Forbion are examples of non-Nordic funds that have invested in Danish life science companies. According to Ernst&Young (2007), Denmark was fourth in Europe in 2006 after France, the UK and Germany with EUR 144 million in venture capital, i.e. about three times as much as in Sweden.

Sunstone Capital was formed by Vaekstfonden and private interests in 2007 and currently has DKK 3 billion in funds under management. Sunstone is an early-stage venture capital investor in life science and technology. Vaekstfonden owns 50% of Dansk Innovationsinvestering, 33% of Seed Capital Denmark and 25% of Nordic Biotech II. Table 6 gives examples of exits and current portfolios for the Danish venture capital firms.

It has been estimated that the 10 specialised biotech funds jointly have about DKK 1.5 billion for new start-ups, a sum that may be too low for the new companies formed every year, even with international capital added (Vaekstfonden 2007). This will be discussed further in Section 6.3.

Table 6: Major Danish venture capital funds investing in life science.

VC fund	Focus	Capital	Period	Example of Danish Portfolio (May 2008)
BankInvest Biomedical Venture	Drug discovery	EUR 400 million	1998-	Exits: Acadia, Borean Pharma, CMC Biologics, Genmab, Neurosearch, Pharmexa, Profound Pharma, Survac, TopoTarget (Zymenex) Active: Ace Biosciences, LiPlasome, NsGene, Santaris Pharma, Zealand Pharma.
Dansk Innovations-investering	Health-care & biotech	EUR 400 million	2000-	Active: 7TM Pharma, Ace Biosciences, Cartificial, Natimmune, Santaris Pharma, Vivostat, Zealand Pharma, Zgene etc.
Nordic Biotech I, II	Bio/ pharma	EUR 50 million EUR 61 million	2001 2005/6	Active: LifeCyclePharma, CuraLogic, Gastrotech, Osteologix, Spree Pharma, Entrop Pharma.
SLS Venture	Life science	EUR 270 million	2003-	Active: Sophion Bioscience, Exiqon, Symphogen, Action Pharma, Nuevolution, PreciSense, Sanos Bio.
Oresund Healthcare	Med-tech		2000-	Active: Alsensa.
Danisco Ventures	Biotech		2001-2007	10 investments/closed.
Novo Nordisk Biotech Fund	NN relevance		1999-	Exits: e.g. Apoxis SA (sold to TopoTarget) Active: No Danish.
Novo A/S Novo Ventures	Life science (wide)	USD 80 million p.a.	1999 Evergreen	Exits/IPO: Combio, LifeCyclePharma, NeuroDan Active: 7TM Pharma, Natimmune, NeuroKey, Nuevolution, PreciSense, Santaris, Symphogen.
Novo Seeds	Start-up		2007-	Active: MycoTeq.
Inventure Capital	Life science	EUR 100 million	Contin. 2006-	Active: Action Pharma, Fluxome, Liplasome, RSP, ReceptIcon Chempaq, FCMB, Medotech, Proxeon, Quantibact.
SeedCapital DK	Start-up	EUR 100 million	2005-	25 new DK-companies (7 medtech).
Sunstone Capital	Life science + technology Early	EUR 400 million	2007-	Exits: (Zymenex) Active: Ace Biosciences, Action Pharma, Atonomics, Chempaq, Dentofit, Egalet, Evolva, Jurag, M2Medical, Millimed, NatImmune, Nordic Vaccine, NsGene, Nuevolution, PreciSense, Santaris Symphogen, Vivostat, Zealand Pharma.

3.4 Strategic public research and incentives for private participation

Denmark has recently made a number of changes to its public systems. Firstly, administration of the universities and innovation-related policies was moved from other ministries (Education, Economic Business Affairs, and Trade and Industry, respectively) to the new Ministry of Science, Technology and Innovation from 2001. There then followed a merger of regions in 2006 and a merger of universities in 2007.

In Copenhagen, the University of Pharmaceutical Sciences and the Royal Veterinary and Agricultural University became new faculties of the University of Copenhagen, making it very strong in life science research. All life science faculties of the University of Copenhagen cooperate with the Technical University of Denmark in the Danish Pharma Consortium, which aspires to take an active part in the new public private Innovative Medicines Initiative (EU-EFPIA, joint technology undertaking starting 2008).

VTU is an Agency under the Danish Ministry of Science, Technology and Innovation. The Agency's activities deal with:

- public research funding, dialogue on priorities of research initiatives
- commercialisation of research, innovation policy
- EU research policy and international R&I cooperation.

The Agency also functions as secretariat to the Danish Research Coordination Committee, the Danish Councils for Independent Research (bottom-up procedures), the Danish Council for Strategic Research, the Danish Council for Technology and Innovation, the Danish Research Policy Council and the Danish Committees on Scientific Dishonesty. The National Research Foundation (Grundforskningsfonden) and the Advanced Technology Foundation (Hoejteknologifonden) have separate secretariats.

NABIIT (Nanoscience, biotechnology and IT & communications technology) was launched as a strategic area in 2005 with a budget of about DKK 100 million per year between 2006-2008. A second life science strategy is the Interdisciplinary research programme on the correlation between food, nutrition and health, with another DKK 100 million per year between 2005-2008. In total, about DKK 400 million or 60% of the funding from the Council for Strategic Research will go to life science in 2008, including DKK 50 million for individualised health studies and DKK 40 million for clinical research.

The *National Research Foundation* (*Grundforskningsfonden*) sets up and funds Centers of Excellence and research schools with about DKK 250 million per year. It also funds a collaborative initiative on bioinformatics

covering three universities, and has started the Niels Bohr Visiting Professorship and a Research Foundation Professors' programme to attract foreign top-level researchers. The Foundation was increased by DKK 3 billion in 2008 (cf. Section 6.4).

The *National Advanced Technology Foundation* (*Hoejteknologifonden*) is an independent body within the government administration that offers grants in the form of co-funding for high-technology research and innovation initiatives and projects. Each initiative or project must meet three criteria:

- obvious commercial potential
- technology transfer
- collaboration between public research institutions and companies.

The Foundation's capital is increased gradually via the annual national budget. The goal is to have a base capital of DKK 16 billion by 2012. The present annual funding is DKK 350 million. Grants can either go to shorter/smaller projects or to larger platforms (DKK 30-150 million, half paid by the Foundation). The very first investment from 2006 was recently evaluated as a success: DKK 10 million in support of a research collaboration between Santaris Pharma and the MicroRNA group at the University of Copenhagen. Santaris Pharma contributed another DKK 7 million, and the MicroRNA group contributed DKK 3 million. This research has developed into a regular part of Santaris' Research Department and since 2006 its number of employees has increased from 44 to105.

A new study of the public research councils indicated that *radical interdisciplinarity* varied from about 1% (Independent Research) to 11% (Strategic Research). The Advanced Technology Foundation had a very high level of interdisciplinary projects, but mostly between science and technology, i.e. closely related fields. It was noted that only calls from the Strategic Research Council and the Programme Commission on Health, Food and Welfare mentioned interdisciplinarity as a positive evaluation factor (DEA, 2008). The same study also included interviews with companies about participation in public R&D projects, with 63% stating that they lack incentives to participate. Thus it was concluded that strategic research had primarily supported university research.

The *Council for Technology and Innovation* has DKK 800 million per year to support regional innovation, interaction and infrastructure between research and industry, commercialisation and entrepreneurs.

Davis & Lotz (2006) interviewed nearly 300 senior researchers at Danish universities and hospitals regarding their collaborations with industry and their motivation for collaborating. They found a very strong correlation between the publication record, number of patents and interest in

collaborations. Interestingly, there was a positive link not only to total number of publications but also to publications in journals specializing in *basic* research, making the authors suggest that channelling research grants into strategically important applied research might be the wrong way to go.

3.5 Incentives for commercialisation - The Act on Inventions at Public Research Institutions

In 2000, Denmark instigated new rules which gave universities ownership of all inventions developed by employees during their work, even when that work is carried out in collaboration with third parties (e.g. industry). This applies unless a university agrees to renounce its rights (in full or in part) prior to initiation of the collaboration.

As a result of these rules, new Technology Transfer Offices, TTO, were set up at every university. Initially they were very small and had little commercial experience (MVA Innovation Report, 2004). They applied for patents, and a study of the first five years (2000-2004) showed that Danish scientists were now participating in fewer industry patents than before the new law.

Of all university patents from 2001-2004, 14 (25%) were within drug discovery and these had a total of 55 inventors from the universities. However, Valentin et al (2006:1) demonstrated that this *equals a deficit of 130 investor contributions to SME* compared with the previous intensity and with the unchanged practices in Sweden (where inventions are owned by the researchers). When Novo Nordisk and Lundbeck were included in the calculations, the estimated loss increased to about 250 Danish academic participations. Thus, the new university patents with 55 inventors only substituted about one fifth.

The authors discuss that the low substitution rate might be due to a "complementarity of interests between the industrial partner and the academic scientists which is not shared by the TTO". It was also assumed that this effect is more evident for discovery phase work, and that the Act on Inventions at Public Research Institutions will generally work better for R&D that is closer to commercial technologies; in diagnostics and medical devices for example.

Thus, the rules initially disrupted public private collaborations, but by the spring of 2008 our few interviews indicated that large companies in particular have organised agreements and are now pursuing work with the Danish academic institutions.

The recent public research commercialisation survey (VTU 2008) covered all universities, research hospitals and several research institutes. The total

number of licences, options and assignments (including software) has settled at a level of just below 100 per year, while the number of new university spin-outs was around 10 per year. Taken together, the commercialisation revenues in 2007 were DKK 3 million higher than the costs for the technology transfer staff (58 full time employees) plus 130 patent applications (selected from 360 disclosures). However, the report does not give any separate numbers for life science-related licences or start-ups.

3.6 The globalisation strategy

The Globalisation Council operated between April 2005 and April 2006 and consisted of five ministers (Prime Minister and Secretaries of Industry, Science Technology and Development, Education, and Finance), five CEOs of large Danish companies (including Novo Nordisk and Danisco), and other representatives from universities, schools, industry associations and trade unions. The year was packed with subgroup discussions and public meetings and resulted in the signing of a document between the government and the Council, whereby industry agreed to participate actively to implement the globalisation strategy. Industry will offer lecturers, mentors, training sites and internships and participate in both research and innovation projects and entrepreneurial activities.

The globalisation strategy specified 350 initiatives, and set very ambitious goals for Denmark to become:

- a leading research nation
- a leading entrepreneurial society
- a country with world-class education
- the most competitive country.

Higher education is to be strengthened by DKK 16 billion. Furthermore, research funding will gradually increase (by DKK 23 billion) in order to meet the goal of a minimum of 1% of GDP by 2010. Thus far, it has increased from 0.71% in 2006 to 0.78% in 2007.

Half the public funding will be competitive, based on applications for long-term research programmes from the universities. Many strategic initiatives will seek co-financing from industry, and will be allocated to areas of relevance to continued advancement of public welfare or which will solve significant problems for society. European and international collaborations will also be prioritised.

An expert group, *FORSK2015*, led by Professor Bente Klarlund Pedersen at Rigshospitalet will propose strategic research themes. Their first report from December 2007 contained the following biotech themes:

- Bioproduction technologies
- Lifestyle and disease prevention
- Health
- Genes and environment, incl. nutrigenomics and bioinformatics
- Role of environment for development of infectious diseases
- Molecular biology-based bedside diagnostics for individualised treatments
- Ageing and chronic diseases.

It is clearly stated that these proposals are based on Danish research strength and expected to support industry and future export.

Innovation and entrepreneurship is supported by increasing the number of students, including PhDs, in “high technology” areas such as biotechnology and medicine. Other initiatives to increase innovations include a programme for user driven innovation and increased collaboration between companies and universities or research institutes.

InnovationDanmark is a work programme for 2007-2010, aimed at improving innovation in Danish industry (VTU 2007) by a number of new or strengthened initiatives implemented by the Council for Technology and Innovation amongst others. The goals for the DKK 3 billion allocated are stated in round numbers, such as 5,000 SMEs to become innovative, 2,000 SMEs to hire highly educated employees, and a doubling of Industrial PhDs.

The initiatives comprise:

- Innovation consortia (continued, with new fields added to reach SMEs)
- Innovation networks within such fields as bioinformatics, health technology, health/IT, bioenergy & environmental biotechnology etc. (continued)
- Knowledge pilots, salary support for highly educated people in SMEs (continued)
- Approved Technological Services (GTS institutes, continued)
- Industrial PhD (strengthened) and Knowledge or Research vouchers (new)
- Proof-of-concept funding (new)
- Innovation environments (to assist in starting 250 new companies, continued).

The *Innovation Environments* assist in the start-up of new companies and also supply the earliest pre-seed/seed capital with up to DKK 1.5 million. The current seven Innovation Environments are: CAT-Symbion Innovation, DTU Innovation, HIH Development, NOVI Innovation, Syddansk Innovation, Teknologisk Innovation and Oestjydsk Innovation. They often invest regionally but not only in university start-ups. For example, DTU Innovation/Seed Capital Denmark has invested in Malmö-based Celltrix AB (Sweden).

About one third of all (not only life science) companies established in the Innovation Environments during 1998-2001 survived until 2006.During 2002 and 2006, another 1,500 projects were evaluated and over 300 start-ups received about DKK 400 million (cf Section 3.3). The contracts between VTU and the Innovation Environments ends in 2008 and, according to InnovationDanmark (2007,) the next call will ask for closer contacts with the universities and their TTOs.

The *Proof-of concept funding* started in late 2007, when two consortia were established, one in Medicon Valley (DTU, University of Copenhagen, Rigshospitalet, SSI) and one for the North, Central and Southern regions (Aalborg, Aarhus and University of Southern Denmark). They jointly receive DKK 40 million to support projects with a maximum of DKK 750,000 per project from 2007-2009 (Vaekstfonden 2008).

Denmark has a long tradition of co-funded Industrial PhDs, and nearly one third of these were within life science between 2002 and 2006 (VTU 2007). The total number of Industrial PhDs will be doubled in 2007-2010. This type of public-private collaboration is seen as an important way of promoting knowledge transfer. Another is via internships and the very common, part-time employment of students in administration and industry.

Table 7: Important partners for co-funded industry PhD programmes.

Company	Number of Industrial PhD projects 2002-2006
Novo Nordisk	65
H Lundbeck	19
Novozymes	16
Neurosearch	10
Oticon	6
Other bio/medtech	33

3.7 Science

The University of Copenhagen was ranked the best in Scandinavia and eighth in Europe by Shanghai Jiao Tong in 2007[6]. More recently, in May 2008, the Technical University of Denmark was ranked 20th worldwide and third in Europe, after Max Planck and Zürich, by the Times Higher Education (THE 2008). The improvement indicated by the higher rankings was also demonstrated in a bibliometric study of field-normalised mean citations, with Denmark taking third place after the US and Switzerland (Vetenskapsrådet 2006). Medicine and Natural Science accounted for 75% of all publications, which was also the case in Sweden.

A bibliometric study covering the years 1990-2007, carried out by VINNOVA, demonstrated that the number of publications in highly ranked journals (impact factor > 6) increased during the 1990s and stayed at consistently high levels from 2000 (Figures 1 and 2). An analysis of the same data for the two countries but in relation to population shows that, unlike earlier years, the volume of publication in Denmark has increased in recent years to become more comparable with that of Sweden. This is especially true in Medicine. However, in Life Science, Sweden still averages a 10% higher publication volume in relation to population for the years 2000-2007.

The Danish publications within Medicine were most frequently co-authored with researchers from the US, UK and Sweden, followed by Germany (Figure 3 and Appendix Figure A). However, Sweden came fifth after the US, UK, France and Germany in other life science areas for 2000-2007 (Figure 3 and Appendix Figure C). In Medicine, Japan, China and India represented Asia among the 30 top countries collaborating with Danish researchers. However, India did not appear amongst the top 30 countries in Life Science.

A comparison of Danish international collaboration with the corresponding data for Sweden indicates international co-authoring in top medical journals to be more common in Sweden than Denmark for most of the top 30 countries. This is especially true concerning collaboration with the US. American researchers are co-authors of 44% of the Swedish articles, whereas the corresponding share for Danish articles is 29%. However, more comparable shares of international co-authoring with researchers from the top 30 countries are found for publications in top life science journals. For example, the co-authoring share with the US is 30% for Sweden and 28% for Denmark.

[6] www.arwu.org

Among universities and hospitals, collaboration with Lund had approximately the same frequency as with other large Nordic entities (Appendix Figures B and D). Novo Nordisk had a publication volume almost corresponding to that of a large university, especially if publications from Hagedorn and the Steno Diabetes Center were included (cf Section 2.2), as previously reported by Wichmann Matthiessen et al (2007).

3.8 Clinical research

After Sweden, Denmark had the second largest number of published controlled clinical trials in the Cochrane Central Register covering 60 years (1946-2006), taking into account the size of the country's population (Gluud and Nikolova, 2007). Denmark was ranked fourth globally for cited publications 2001-2003 (SOU 2008:7 p 129). Furthermore, the mean citation rate for the publications increased from about 0.9 in 1990 to over 1.1 in 2002 and 2003. This is similar to the positive development in Switzerland but different from Sweden, where the mean citation has varied close to 1.0 (SOU p. 133).

The Danish Association of the Pharmaceutical Industry (Lif, 2007) published a study on clinical research activities among its member companies. They spent DKK 1.5 billion on clinical research in Denmark, including nearly 250 company employees involved in clinical research management (still only 1/5 of the internal personnel, the others managing international studies). The number of clinical studies reported by the 23/25 companies are given in Table 8.

Table 8: Clinical studies in Denmark according to Lif (2007).

Year	Phase I	Phase II	Phase III	Phase IV	Total	No of patients	Patients per study
2005	9	65	133	77	284	20,713	73
2006	15	68	162	101	346	19,187	57

Five companies had over 30 studies running in Denmark in 2006, and the total number of studies (and studies per company) increased from 2005 while the number of patients involved and total external costs were constant or even lower. Direct payments to the public health sector amounted to some DKK 330 million per year, with nearly 10% (DKK 30 million) for investigator-initiated projects.

A good infrastructure, including big registries of patient data, electronic patient journals, Good Clinical Practice units at the university hospitals and a positive view in the population towards participation in clinical trials, have

been important factors in this strong position. However, there is a fear that future trials will move outside Denmark, since young clinicians appear to lack both time for and interest in conducting clinical studies. A new strategic programme has thus been instigated from 2008. This will be described in more detail in chapter 6.

Figure 1 Number of publications in highly ranked life science journals with impact factor >6 (excl. journals in clinical medicine)

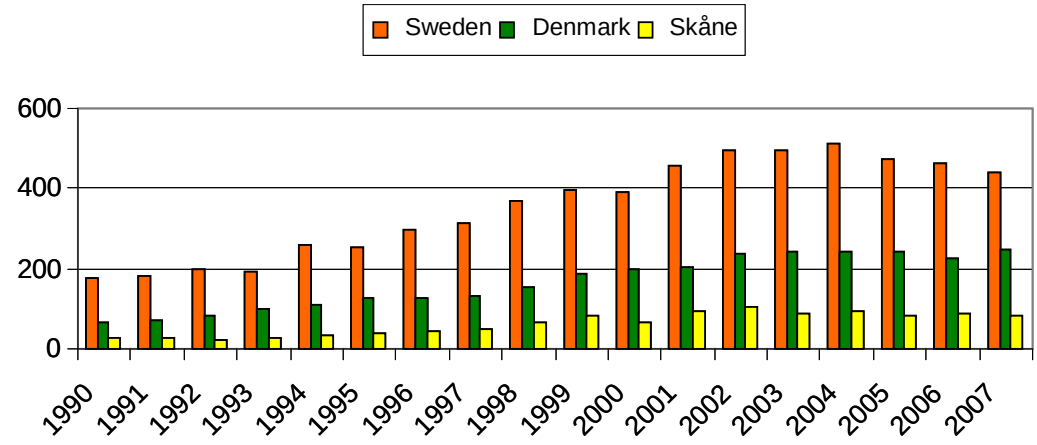
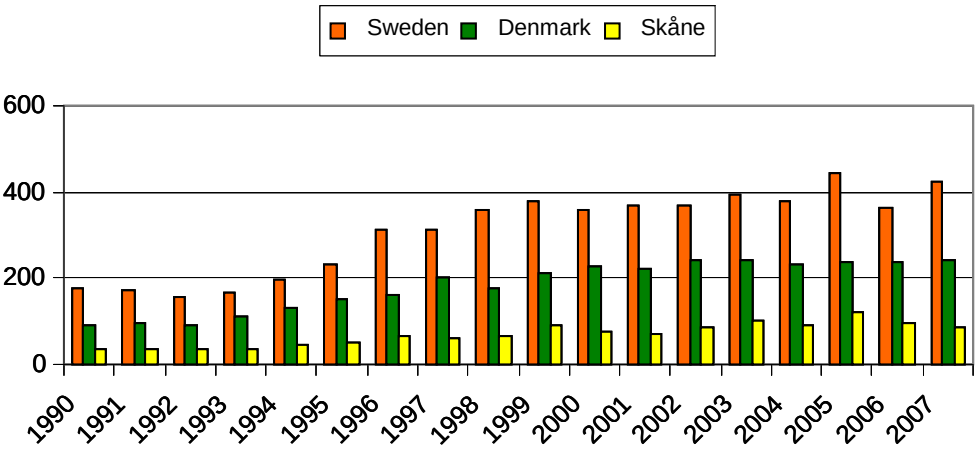
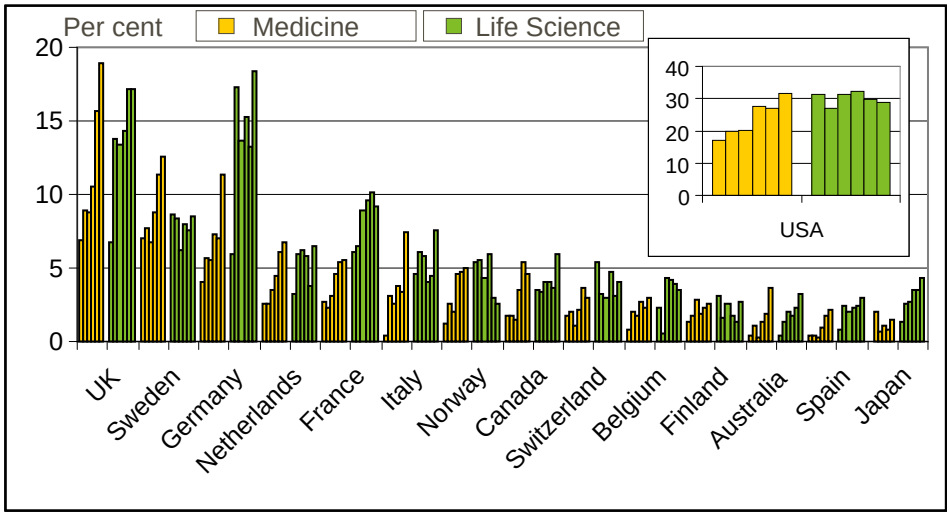


Figure 2 Number of publications in highly ranked medical journals with impact factor > 6



Figur 3 Share of Danish publication volumes in top medical and life science journals 1990-2007 co-authored with researchers from other countries distributed into six time periods



3.9 Conclusion regarding public initiatives

In conclusion, the many recent administrative changes in Denmark, i.e. the merger of regions, the merger of universities, the reorganisation of VTU, the Agency for Science, Technology and Innovation, the implementation of new strategic programmes for research and innovation, as well as research collaborations via the Advanced Technology Foundation, are all too recent to have had an impact on the life science industry during 2006.

Even the impact of the Act on Inventions at Public Research Institutions was not easily traced, since most of today's growing companies are developing ideas and technologies which were invented before the Act came into force. The present study did not include all "project companies" around the universities, unless those companies were clearly recognisable with their own employees. The Innovation Environments from 1998 and onwards have supported many start-up companies but only few have made exits this far, which means that the basis for evaluation is fairly small.

Vaekstfonden has proved important, especially during the difficult years of 2003-2004 when other venture capital funds were reluctant to invest, but also with the soft loans before 2001. Without Vaekstfonden, many of today's rising stars might not have survived.

4 Life science industry 1989-2007

4.1 Status for life science industry

The present status of the life science industry in Denmark is based on a mapping of figures for 2006, analogous with the VINNOVA report on Sweden (VINNOVA, 2007). The employees of companies aiming for an international market and with R&D and/or production in Denmark were counted. The life science industry therefore includes:

PHARMACEUTICALS: drug discovery and development, drug delivery, diagnostics, CRO (pharma), drug production, bioproduction.

BIOTECHNOLOGY: drug discovery and development, drug delivery, diagnostics, CRO (biotech), drug production, biotech tools and supplies, biotech medical technology, bioproduction, agricultural, industrial, environmental and food-related biotechnology

MEDICAL TECHNOLOGY: biotech medical technology, diagnostics, healthcare equipment, active and non-active implantable devices, biotech medical technology, anaesthetic/respiratory equipment, dental devices, audiological devices and hearing aids, electromedical and imaging equipment, ophthalmic devices, surgical instruments and supplies for electromedical and imaging applications, medical disposables, CRO (medical technology), and IT & training.

Since some activities are found in several sectors, the sum is more than 100%. For Table 9 and Figures 4 and 5, the drug related activities have been merged and all double counting removed in order to allow a presentation of the relative shares.

Table 9: Life science companies with R&D and/or production in Denmark in 2006.

265	Number of large and small enterprises with own employees
80%	Based in Medicon Valley (Regions Sjaelland and Copenhagen)
20%	Based in NCS Denmark (North, Central and Southern regions)
55%	Active in drug related areas i.e. drug discovery & development, drug delivery, diagnostics, drug CRO, drug production including Novo Nordisk bioproduction
25%	Active in Medtech except biotech medical technology, diagnostics
20%	Active in Biotech except the drug related areas listed above

The centre of life science activity is clearly the Danish part of Medicon Valley, with about 80% of the companies (Table 9) and over 90% of the employees (Table 10). The North, Central and Southern regions had 55 companies or units with their own research and/or production in 2006, and about 3,000 of the 40,000 employees. Larger companies with units in NCS Denmark include Danisco, Coloplast, Fertin Pharma and Interacoustics. Novo Nordisk and Nycomed have small production units. The contract research organisation CCBR, now owned by Synarc, is in Jylland and new start-ups are found close to the universities of Århus, Ålborg and Odense.

The vast majority of the companies operate in health-related areas, mostly biopharmaceuticals but many also in medical technology. One in four offer some kind of contract services, and 16% are contract research organisations (CROs) but these have only 2% of the employees (Figs 4 and 5).

Table 10: Employees in life science companies with R&D and/or production 2006

40,000	Total number of employees (39,375 full time equivalents)
67% 33%	Employees in R&D and administration Employees in production
60%	Employed in the ten largest companies: Novo Nordisk, Leo Pharma, Novozymes, Coloplast, Lundbeck, Danisco (excl. sugar), Oticon, SSI, NNIT, Radiometer
37,000 *+10%*	Employed in Medicon Valley Estimated increase from 2003

Figure 4 Companies per selected segment 2006

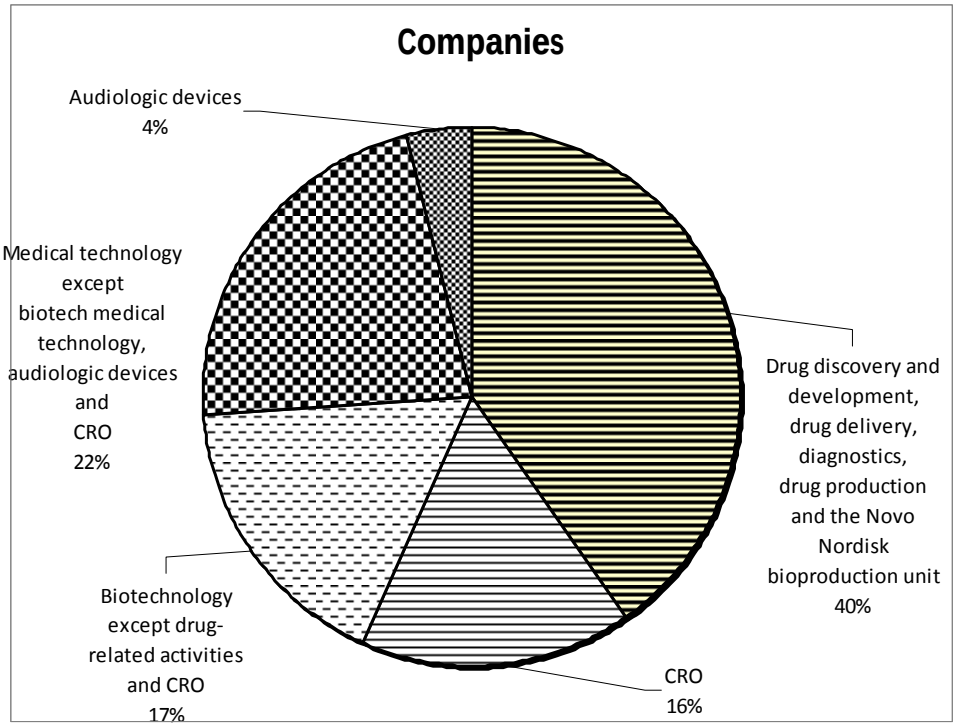
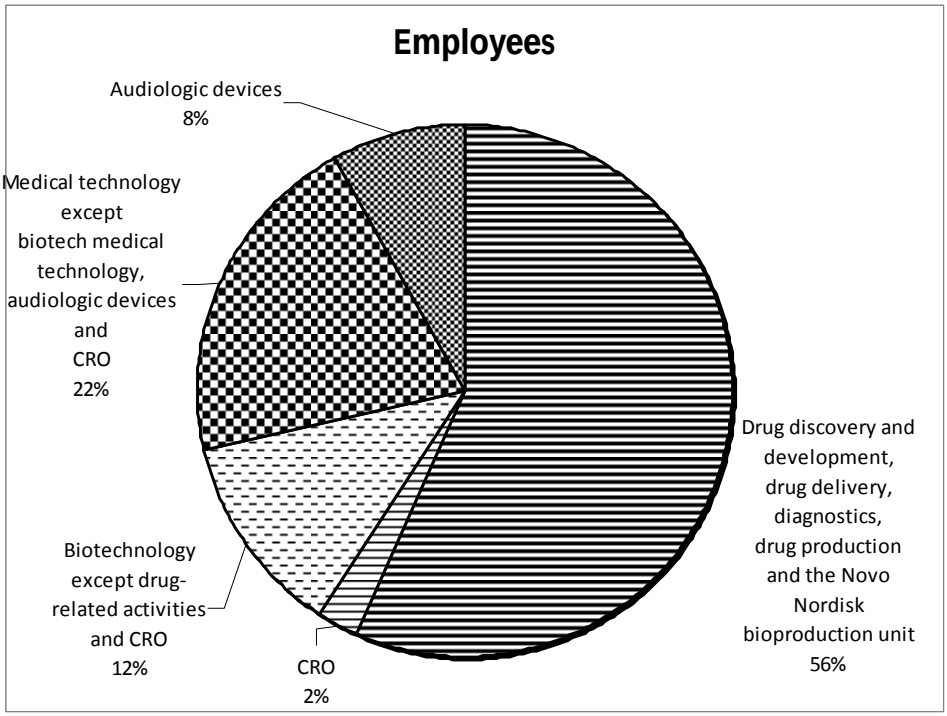


Figure 5 Employees per selected segment 2006



The mapping for 2006 is not directly comparable to the one from 2003, which only covered Medicon Valley and had a narrower definition of

medical technology (it did not include audiological devices, for example). A comparison of 160 companies, which was included in both studies and took into account companies that had closed or opened since 2003, revealed an increase in the number of employees by nearly 10 %. This growth trend was also confirmed through interviews with representatives of several large companies. They stated that the companies must attract more personnel, possibly from Sweden and other Baltic countries. Thus, in spite of research and production units being established outside Denmark, the companies still need additional competences and staff in Denmark.

4.2 Life science start-ups 1989-1996

Before turning to the start-ups from the last decade, it is worth looking at a few companies that were started some years earlier but which are still in development and have been important to several spin-outs.

NeuroSearch is one of the oldest Danish biotech companies, founded in 1989, and with an unusual start - having no patents of its own but relying on an experienced management team (from Ferrosan) and a legendary chairman. After 20 years, with 239 employees, 11 substances in clinical trials and a market capitalisation close to DKK 5 billion, the company has reached the pivotal phase III studies (for obesity and Huntington's disease). Partnerships with GSK, Abbott and Astellas are yielding milestone payments and possible future royalties. NeuroSearch has four subsidiaries, NeuroSearch Sweden (formerly A Carlsson Research), Poseidon Pharmaceuticals, NS Explorer and NeuroScreen. Furthermore, the company is involved with a number of spin-outs and associated companies, including NsGene (CNS-biologics), Sophion Bioscience (HTS-Ion channels), Atonomics (Diagnostics-POC), Zgene (Cancer Gene Therapy), PainCeptor (CNS-Ion channels) and Bavarian Nordic (Vaccines).

Bavarian Nordic was co-founded by Neurosearch in 1994 to develop vaccines. The company made an IPO in1999, acquired GenTherapeutica (Germany) in 2003, and the same year obtained its first contract with the US authorities for development and production of a safe smallpox vaccine. Additional contracts have followed for supply of 20 million doses, and options for many more. Manufacture takes place north of Copenhagen in a pharmaceutical production unit which formerly belonged to Orion Pharma. A subsidiary, BN Immunotherapeutics Inc., was started in Palo Alto in 2004 for research on cancer vaccines, and phase I/II studies were recently initiated in the US. The company had 120 (of 264) employees in Denmark in 2007.

Exiqon was started in 1996 to commercialise an invention from the University of Copenhagen. The new photochemical method for binding

biomolecules to surfaces was soon used by Nunc to produce functional ELISA plates, giving revenue to Exiqon. In 1998, Exiqon bought a second university invention, the LNA (Locked Nucleic Acid) technology. Since Exiqons's core business was diagnostics, the therapeutic applications were licensed to what is now Santaris Pharma and production and sales for research use were licensed to Proligo, Inc. These deals provided downpayments, milestones and future royalties. As with many other young biotech companies, Exiqon's development and IPO was delayed by the terrorist attacks in September 2001, and its listing on the Copenhagen Stock Exchange was not completed until 2007. Exiqon then acquired California-based Oncotech, Inc. for DKK 225 million (6 million new shares) and entered the cancer molecular diagnostics field. It recently started a research collaboration in cancer diagnostics with the University of Copenhagen and Rigshospitalet, supported by Hoejteknologifonden (the National Advanced Technology Foundation).

Table 11: Public listing of companies started 1987-1996.

Company	Origin	Year Started	Year of IPO	IPO (DKK (millions))	Present market cap (May 2008, DKK (millions))
NeuroSearch	Industry	1989	1996	240	~4,500
Bavarian Nordic	Industry	1994	1999		1,700
Exiqon	Academy	1996	2007	350	900

4.3 Life science start-ups 1997-2006

Over half the life science companies in the 2006 mapping were established in Denmark after 1997. The peak period was between 2000 and 2002, and most of the newly established companies were active within biopharmaceuticals. Jointly, the new companies had about 2,600 employees in 2006. A comparison of the companies in Medicon Valley with the 2003 study indicated an increase of about 30%. Employees of companies closed or started since 2003 were then removed or added.

Table 12: Companies with R&D and/or production started 1997-2006.

146	Number of companies
77% 23%	Based in Medicon Valley Based in NCS Denmark (North, Central and Southern Regions)
55%	Active in drug related areas (drug discovery & development, drug delivery, pharma diagnostics, drug CRO, drug production
25%	Active in Biotech except drug related areas
20%	Active in Medtech except biotech medical technology and diagnostics
2600	Total number of employees
2000 *+30%*	Number of employees in Medicon Valley Increase from 2003
14	Number of companies listed on the stock exchange

There is roughly an equal number of industry spin-outs and university start-ups among the new companies. It is interesting to notice that not only large companies such as Carlsberg, Lundbeck and Novo Nordisk are behind spin-outs, but also young SMEs like Neurosearch from 1989 and Nordic Bioscience from 2001. As expected, the university start-ups come from the Technical University of Denmark, University of Copenhagen and university hospitals in Copenhagen, as well as from Aarhus, Aalborg and Odense. But often the company founder is an experienced industry manager rather than a university researcher.

Table 13: Origin of life science companies with R&D or production, started 1997-2006.

146	Total number of companies
55% 45%	Start-ups from Academy (examples of origin below) Spin-outs from Industry (examples of origin below)
Academy	e.g. DTU, University of Copenhagen, Aarhus University, University of Southern Denmark, Aalborg University
Large enterprise	e.g. Carlsberg, Lundbeck, Novo Nordisk, Danfoss
SME	e.g. Neurosearch, CCBR, Symphogen, Nordic Bioscience
8%	Foreign establishments in Denmark
2%	New companies based on imported IPR (e.g. Genmab, Symphogen)

If we consider listing on the stock exchange as a measure of success, there is no clear distinction between IPOs according to origin, so much as in timing and market capitalisation, see Table 14. According to Ernst&Young (2007), Denmark is unusual in that most of the biotech employees work in listed companies. At the same time, there are not as many new companies on small lists as in Sweden.

With the life science definition used in our mapping, about two thirds of the employees are in listed companies, including those listed outside Denmark. However, the present economic situation makes it less likely that the IPO-route will be chosen by new candidates.

Table 14: Public listing (IPO) of life science companies started 1997-2006.

Company	Origin A=academy I =industry	Year started	Year of IPO	IPO (DKK (millions))	Market cap (May 2008, DKK (millions))
M&E Biotech/ Pharmexa	A/I	1997/90	2000	About 1,000	200
Genmab	I (US)	1999	2000	1,900	12,000
Topo Target	A	2000	2005	225	800
Life CyclePharma	I	2002	2006	500	1,500
Osteologix*	I	2003	2006	50	20
Curalogic	A (US)	2004	2006	200	200

**) Osteologix listed on Nasdaq OTC via a reverse merger with Castel & Morgan Holdings*

Other measures in the new companies are international deals or product launches. International big pharma and big biotech seem very interested in the new projects developed in Denmark, and a number of large deals have been signed over the years. As expected, deal sizes increase with the maturity of projects, i.e. from preclinical platform technologies to clinical phases I or II, cf Table 15.

Table 15: Examples of international deals by companies started 1997-2006.

Company	Origin	Year started	Year of deal	Project Phase	Partner	Upfront payment+ equity invest (DKK (millions))	Potential total gain excl royalty (DKK (millions))
Zealand Pharma	A	1998	2003	I	Sanofi-Aventis	50	500*
Genmab	I	1999	2006	II	GSK	2,000	10,000
Santaris Pharma	I	1998	2007	Platform	GSK	40	3500
Zymenex	I	1998	2008	II	Shire	700	-
Symphogen	A	2000	2008	Platform	Genentech	Undisclosed	>1500

** Sanofi-Aventis initiated Phase III studies in 2008*

It is primarily companies developing biotech tools and medical technology that have a possibility of reaching the market within 5-10 years. However, a few pharmaceutical products have already been approved for marketing, cf. Table 16. Furthermore, a number of service providers could also be added, such as Pipeline Biotech (A/1999), Ice (I/2000), Vivolution (I/2000), CMC Bioscience (I/2001), and BioAdvice (I/2003).

Table 16: Example of first products marketed by start-ups 1997-2006.

Company	**Origin** **I=Industry** **A=Academy**	**Year** **started**	**Year of launch or approval**	**Product (Indication)**
BioPorto Diagnostics	I (SSI)	2000	2000	Antibodies for research
Sophion Bioscience	I (NeuroSearch)	2000	2004	Patch clamp systems
Visiopharm	AI (DTU-Torsana)	2001	2004	Medical imaging software
Chempaq	A (DTU)	1999	2005 (US 07)	POC hematology analyser
Proxeon (Protana/MDS)	A (U of South. Denmark)	1997/ 2002	2006	Proteomics products / equipment
Topo Target	A (Rigshospitalet)	2000	2006	Savene/Totect (Indication: anthracycline extravasation)
Life Cycle Pharma	I (Lundbeck)	2002	2007 (US)	Fenofibrate (Indication: dyslipidemia)
Virogates	A (Hvidovre Hospital)	2000	2008	SuPARnostics prognostic test

Some of the companies from the last decade were international firms establishing a presence with R&D and/or production in Denmark (Table 17). It is assumed that the interest from CROs (contract research organisations) is caused by the cluster, with many companies as potential customers, combined with the current trend to outsource more research and production. A handful of biotech companies are almost virtual, with all research outsourced. One example is Colotech, running a clinical study in Phase III with two employees and a long list of cooperation partners. More common are young project/companies in the Innovation Environments.

Table 17: Examples of international companies establishing subsidiaries 1997-2006.

International	Origin	Acquisition	Year	Activity
TFS	SE	-	2000	CRO
Maxygen	US	ProfoundPharma	2001	R&D
BiogenIdec	US	-	2003	Production units
Sterigenics	US	-	2003	Production unit
Encorium	FI	Meddoc	2003	CRO
tebu bio	NL	-	2003	CRO
Arpida	CH	Combio	2004	R&D
Genzyme	US	Verigen	2006	R&D
ThermoFisher Sc.	US	BioImage	2006	R&D
Xendo	NL	-.	2006	CRO

4.4 Comparison to published studies

Most of the publications on Danish biotech development exclude medical technology and study *dedicated biotech firms*. Bloch (2006) found 184 such firms with a total of nearly 4,800 employees in 2003. Pharmaceutical companies with only sales and distribution were not included, nor were large enterprises with only part of their innovative activities within biotechnology. The study also reported a doubling in total biotech R&D costs from 1997 to 2003, i.e. from DKK 3 to 6 billion worth of intramural research or 1/4 of total private sector R&D in Denmark in 2003. During this period, extramural research increased from 20% to over 30%. This was due to large companies outsourcing R&D to firms abroad and SMEs which primarily outsourced to public research organisations, including hospitals, in Denmark.

Table 18: Dedicated biotech companies started per year since 1997.

Year	(Pre)	1997	98	99	2000	01	02	03	04	05	06	07
New start-ups	(32)	3	5	8	15	17	13	8	9	6	6	10

Source: Dansk Biotek (2007, 2008). Only still existing companies were included

According to Dansk Biotek, the number of *surviving* dedicated biotech companies was 122 in 2006 and 127 by the end of 2007. Since this number

is lower than the one from Bloch (2006), it appears that over 50 companies may have ceased to exist due to mergers and acquisitions, unsatisfactory results or bankruptcy. However, it may also reflect a difference in characterising dedicated biotech. In the present study, we estimated the biotech group with their own employees at132 companies in 2006, including a few biotech CROs.

More evident from Table 18, the number of biotech start-ups per year is now at a lower level than during the peak period of 2000-2002. Vaekstfonden (2007) published a report, *Venture capital and biotechnology in Denmark*, based on interviews with 25 central actors regarding their views on the current biotech start-up activity, public research and available venture capital in Denmark. The biotech definition included drug development, therapeutics, industrial biotechnology and nutraceuticals but not medical technology. In this category, they found about 120 active firms with a total of over 30,000 employees - 80% in the five largest biotech companies, i.e. Novo Nordisk, Danisco. Lundbeck, Novozymes and Leo Pharma. Only 30% of the firms had a turnover above DKK 100 million, and the total turnover estimate of about DKK 80 billion was dominated by the five largest plus ALK Abelló. The total revenue was about DKK 15 billion, but over 150 firms reported deficits totalling DKK 2.6 billion. Turnovers and revenues had increased by 29% relative to 2002 and the number of employees by 21% (cf. Table 19).

Table 19: Relative turnover, revenue (pre-tax) and no. of employees 2002-2006.

Year	2002	2003	2004	2005	2006
Revenue	100	111	114	134	129
Turnover	100	103	109	123	129
No of employees	100	104	107	119	121

Source: Vaekstfonden (2007) from Fig 2.6

It is interesting to compare the employee increase from 2003 to 2006, some 16%, with our study which shows that Medicon Valley life science companies increased their employees by about 10% (Table 10). This difference must be due to a smaller employee increase in Denmark in the medtech companies than in pharma plus biotech.

Vaekstfonden (2007) also counted pharmaceutical projects in preclinical and clinical phases, claiming that Denmark had the highest number of clinical projects *per million inhabitants* and was second in terms of clinical projects *per biotech firm*. As expected, the projects were primarily found in early clinical phases, matching the young age of many companies.

Ernst&Young (2007) listed pipeline information from public and private Danish companies in 2006. The Medicon Valley organisations published similar data, with nearly 200 indications under testing when companies in Skåne were included (Medicon Valley 2007).

Table 20: Projects in preclinical and clinical development.

Projects	Preclinical	Phase I	Phase II	Phase III	TOTAL
Public firms	28	18	26	5	77
Private firms	36	20	16	2	74
ALL	64	38	42	7	151

Source: Ernst&Young (2007). Only data for companies reporting pipeline information was included.

The numbers reflect a young but maturing industry with continued growth potential. The absolute numbers are very high and the survey showed the companies in Denmark to be significantly larger than in many other European countries. On average, they have seven products per company in clinical trials. While Swiss companies have eight, all others, including Great Britain and Germany, have 3-5 products per company. This strong product development is more important for a high valuation by VC firms than new technologies as such (Ernst&Young 2007).

Danish biotech industry's favourable position can thus be read by investor interest in the companies. The Danish biotech companies succeeded in attracting the fourth highest venture capital sum in 2006 – approximately DKK 1 billion (EUR 144 million, cf Section 3.3). The next chapter will discuss possible factors behind this success.

5 Important factors for development of new life science companies

The Research Centre on Biotech Business at Copenhagen Business School has conducted a series of studies into the development of Danish biotech and compared this to the situation in Sweden. They looked at such things as:

- drug discovery strategies
- origin/founder of the new start-ups
- venture capital/first investment round
- project and patent productivity
- number of employees.

Vaekstfonden (2005) studied the importance of boards, i.e:

- board/globalisation, networks, competences.

Their studies are summarised in this chapter.

According to Vaekstfonden (2005), the average board of a start-up life science company in Medicon Valley (Danish and Swedish companies) has two investors, one founder, one industry expert and one professional board member. A majority of the board members were under 50 years of age, due to a large number of young entrepreneurs and investors. Female board members were scarce in both countries (8 or 9%) and most commonly, the only woman was the industry expert with a key competence from clinical development. On average, the Danish boards had 14% non-Scandinavians and a total of 24% non-Danes in the boards. In comparison, the Swedish companies in the survey averaged only 4% non-Scandinavians and 16% non-Swedes. Since an international network and experience is very important, the composition of Danish boards may be a success factor.

Valentin et al (2006) exemplified different drug discovery strategies with two companies, one with a small molecule approach and the other with a biopharmaceutical technology. Their strategies allow different possibilities for broadening the project portfolio. The authors suggest that the biopharmaceutical approach makes addressing new disease areas easier thanks to a more heterogeneous knowledge platform. The small molecule approach does not work by adding further potential disease targets to the portfolio but by building broader, homogenous knowledge on particularly promising therapeutic pathways. This could be another explanation for the success of the many biopharmaceutical start-up companies and their impressive international deals.

Dahlgren and Valentin (2007) found that the majority (67%) of founders of Copenhagen drug discovery firms came directly out of pharmaceutical companies and another 13% from closed-down firms. Only 20% of the founders were from public research organisations. This was strikingly different from the situation in Stockholm-Uppsala, where nearly 70% of new start-ups were founded by researchers from the universities. The authors argue that a position in a running company offers possibilities for incubating the concept of a new firm and picking the "right moment" for the start-up; again something that can improve the chances of success.

A related difference between Copenhagen and Stockholm-Uppsala might be that of early venture capital. Dahlgren and Valentin believe it is crucial for an experienced pharma manager to obtain sufficient financing right from the outset. New Copenhagen firms have been successful in securing higher amounts in the first and subsequent financing rounds compared to the Stockholm-Uppsala start-ups. Initial financing is often more dependant on local venture capital than the later stages, which may also have helped the new Danish companies. The local presence of large companies with their own investment firms (e.g. Novo A/S) is also important where it concerns contributing venture capital to start-ups.

The investments per employee were about twice as high in Denmark as in Sweden both before and after the difficult period of 2002-2003 (Valentin et al, 2006). In addition, the authors found that the number of patent applications increased and was fairly constant per employee (one patent per 13 employees over the eight-year period). During the same period, the number of projects in clinical phases also increased from one to nearly three per firm. Sweden had more employees per company in 2004, but only because of Biovitrum with nearly 600 employees. If this single large company is excluded, the average for SMEs becomes 21 employees in Copenhagen and 15 in Stockholm-Uppsala. This is despite the Danish companies being younger, with 38 (80%) founded after 1997 as compared to 21 (50%) in Sweden. Thus, the number of patents and projects in clinical phases were higher in Danish SMEs.

There appears to be a logical correlation between new companies with experienced founders, international board members and larger investment rounds on the one hand, and a faster increase in the number of employees, patents and clinical projects on the other.

6 Current trends

The most obvious trend is globalisation and the international collaborations and sales deals that follow. The life science industry in Denmark seems to cope well when trying to utilise globalisation to its own advantage.

6.1 Mergers & Acquisitions

The trend towards mergers of pharmaceutical companies and, more recently, the acquisition of biotech companies has not had much negative impact. Many large Danish companies, regardless of whether they are active within pharma, biotech or medtech, are controlled by foundations and thus largely protected from takeover. Medium-sized companies such as the diagnostics company DAKO and biotech company Chr. Hansen have been acquired by international equity firms after shares were sold (by Novo Nordisk and the Lundbeck Foundation respectively). However, both companies continue to operate in Denmark, and Chr. Hansen is now making its largest investment ever in a new production unit (cf. Section 2.1).

Nevertheless, there are two recent examples of companies leaving Denmark following mergers and acquisitions. Nycomed moved the headquarters of the new, enlarged Nycomed (12,000 employees worldwide) to Zürich after its merger with Altana Pharma in December 2006. Nycomed had 700 employees in Denmark in 2006, a number which still seems unchanged. In 2002, US-based Maxygen acquired Profound Pharma and conducted research with about 70 employees in Denmark, but the company has now left to pursue clinical development in the US (cf Section 3.2).

Sales or out-licensing of projects are necessary for the biotech companies to support their own research and development activities and has been practised with great success as described in Sections 4.2 and 4.3. These deals are expected to become even more important during the present decline in the stock market. No life science IPOs have taken place since May 2007 (Exiqon) and none are expected at present, in spite of several very good candidates.

Some projects/small companies have been acquired within the region or within Scandinavia. Novo Nordisk bought Versamatrix, a Carlsberg start-up from 2004, and integrated it into existing departments. Nordic Phytopharma was sold to Sweden in 2007, and Medimush/Glycanova to Norway. An interesting move within Medicon Valley was carried out by Acadia Pharmaceuticals in 2005, when the Danish half of the US-based company

moved to new facilities in Malmö and became Swedish with about 45 employees.

A recent example of a Scandinavian company establishing a large unit in Denmark is the Norwegian Pronova BioPharma's new production unit under construction at Kalundborg. This is an investment of about NOK 1.5 billion and will employ 85 new full-time equivalents by the end of 2008.

It should be noted that Danish life science companies themselves may grow via mergers and acquisitions. TopoTarget was started in 2000 but has already acquired three companies in the UK, Germany and Switzerland. TopoTarget also bought back the US and rest-of-the-world rights for Belinostat (cancer treatment) from its former partner, Curagen Corporation. Other examples of international M&A include NeuroSearch's purchase of Carlsson Research from Sweden, NNE buying Pharmaplan from Germany (2007), and Exiqon's recent acquisition of California-based Oncotech.

Many Danish medical device companies have grown via a series of mergers, and the trend towards moving production units out has been ongoing for years, so that much manufacturing is already abroad. Several of the larger medtech companies are not Danish-owned, for example Radiometer which is part of Danaher Corporation and William Cook Europe which was established in Denmark back in the 1960s. The hearing-aid firm GN Resound was anticipating a merger in 2007, but this was never realised and the company continues on its own.

6.2 Out-sourcing and alliances

Several start-ups have internal management only, with all other activities outsourced, right up to phase III clinical trials, such as Colotech (cf Section 4.3). As a result, there is an increase in the number and size (both locally and internationally) of contract organisations conducting everything from discovery to preclinical development, formulation, clinical trials, manufacturing and regulatory affairs. Furthermore, some work can be carried out via alliances rather than as pure contracting.

Valentin & Dahlgren (2007) studied when and why alliances (upstream, horizontal and downstream) are regarded positively by the venture capital investors. Apart from the very big international deals, alliances are only positive when other funding possibilities are not sufficient, i.e. when there is a shortage. In these situations, it may be wise not to conduct in-house research and rely instead on agreements with universities. However, pharma-alliances which allow continued project development seem to be neutral when valuing an SME.

6.3 Seed and Venture Capital

Even in a country with good international contacts and a decent number of venture capital firms, the supply of capital might limit rates.

Vaekstfonden (2007) estimated that 10 specialised biotech VC firms jointly hold about DKK 1.5 billion for new start-ups. With a trend towards an increased capital need prior to exit, perhaps DKK 400 million per new company according to Vaekstfonden, the total capital is much too low even with international syndication. The number of start-ups is lower today than during the golden years around 2000, and among the explanations given are

> *"tougher requirements from investors", "lack of capital and management", and "a changed framework for commercialisation".*

The newer start-ups come primarily from the universities, and those interviewed by Vaekstfonden were critical of the implementation of the new Act on Inventions at Public Research Institutions. The TTOs were said to concentrate on licence agreements rather than start-ups. In part, this was due to a lack of proof-of-concept or pre-seed/seed money to help a project mature to a stage where it could become the basis for a start-up and attract venture capital. The early seed money is mainly from Innovation Environments (incubators) and public funds. However, some positive effects should be seen by the Globalisation Council's DKK 40 million (2007) proof-of-concept initiative and the new Novo pre-seed capacity and seed fund of DKK 100 million, also launched in 2007.

Some of our interviewees expressed concern about the existing venture capitalist firms becoming too risk-averse. There may be a need for Vaekstfonden to offer more early support, maybe via old fashioned soft loans of the type that helped many start-ups in the 1990s.

6.4 Public research and innovation

Danish public research spending will reach 1% of GDP in 2010, according to the aims of the Globalisation Council (cf. Section 3.7). The research costs increased by 10% to DKK 14 billion or 0.78% of GDP in 2007. Although the National Research Foundation (Grundforskningsfonden) was recently increased by DKK 3 billion and will now be able to support DKK 400 million worth of research per year, a nationwide petition has been started in time for the 2009 review of the Danish University Act of 2003. The petition demands less strategic research money, less top-down governing of the universities, and more academic freedom. In contrast, the industry organisation Dansk Industri asks for focus on strategic research, as proposed

in FORSK2015 (cf Section 3.7), as well as reduced tax rates to secure competent manpower in the country.

It is probably safe to believe in continued support for research of importance to the Danish export industry. The work of building COBIS, a new bioincubator close to Righospitalet in Copenhagen, starts in the summer of 2008. Furthermore, a new initiative with knowledge and research vouchers for small and medium-sized enterprises (SMEs) was launched in June 2008. SMEs will be able to buy new knowledge for up to DKK 100,000/company or start research collaborations with universities for DKK 1.5 million/company, provided they allocate their own resources (VTU 2008).

6.5 Policies for attracting clinical trials

The international trend of moving clinical trials away from Scandinavia and Western Europe to new EU countries, Russia and Asia, or the US, is one reason for a new strategic programme worth DKK 50 million per year over three years (2008-2010) allocated to clinical research (VTU, 2008). This was the outcome of discussions during 2007 between public and private stakeholders about a national clinical research strategy.

The strategic research programme is directed at:

1 patient-related research focusing on patient outcome.
2 intervention research, with comparison of treatment alternatives and focusing on risk behaviours and risk groups that can be reduced.
3 health services, focusing on comparing new alternatives for organising diagnostics, treatment and follow-up of patients and including studies on the division of work between personnel groups in the healthcare system.

Intended effects of the 10-15 projects discussed (each receiving DKK 10-15 million) include:

- strengthening clinical research environments and collaborations
- strengthening international collaborations and improving the possibilities for attracting researchers from abroad
- promoting positions for researchers at postdoc level in combination with clinical work.

The programme will also promote private co-funding from the pharma and medtech industries.

A new regional programme in the Capital Region of Denmark/Copenhagen will also prioritise clinical research (MandagMorgen 2008, Implement/COWI 2008).

None of our interviewees expressed concern about clinical research in Denmark. Historically, there were no strategic initiatives in this field, but the new ones from 2008 are welcome. It was pointed out that the ongoing doubling of PhD students and improved research infrastructure at the hospitals will also be positive for clinical research.

6.6 Biotech outside the health area

Despite a lot of focus on biotech within medicine and health, the Danish biotech is still firmly rooted in the food industry and has expanded into biomaterials and biofuels, thanks in particular to the rapid growth of Novozymes and Genencor/Danisco. With the new emphasis on Climate, Environment and Energy and the upcoming international climate conference in Copenhagen in 2009, these areas will become even more important.

7 Conclusions

The development of Danish life science into an industry with a profound impact on the present and future export income of the country is impressive. The new companies, about as many academic start-ups as industry spin-outs, are growing in a cluster which enjoys direct and indirect benefit from the large, old biotech, pharma and medtech corporations. Both large and small enterprises are involved with public research institutions and hospitals, with the Globalisation Council as the most obvious example of how industry is participating in strategic planning for the country. While the idea of a Globalisation Council has already been exported to Sweden, there are a number of other frame conditions and priorities that could be considered.

Many of the important factors behind the Danish life science industry cannot easily be mimicked:

- the country's dependence on the life science industry (> 5% of GDP)
- the many century-old, large companies with niche strategies
- the control of the these companies by wealthy foundations
- the foundations' support for research and innovation (incubators/seed)
- the entrepreneurial business tradition with roots in food production
- the Medicon Valley cluster comprising several hundred large, medium and small enterprises, plus large universities and hospital regions.

It should be possible to adapt other factors, at least to Swedish conditions:

- the excellent general business conditions with such things as:
  - × low administrative burden
  - × low-to-medium corporation tax (and lower labour costs than in Sweden)
  - × high mobility thanks to employment flexicurity
  - × more flexible tax rules for foreign specialists
- international directors on the boards, including in start-up companies
- industry-experienced founders/entrepreneurs in start-up companies
- large, early investment rounds in new companies
- a focus on niche strategies
- the government's commitment to research as a means of coping with globalisation
- the many contacts between government and industry
- the large co-funded industry PhD programme

- the tradition of students holding part-time jobs in administration and industry
- national and international promotion of life science clusters.

There are changes of frame conditions which are too new to evaluate, or where the opinions at this stage are divided, for example:

- the Act on Inventions at Public Research Institutions
- the merger of universities
- the public research focus on strategic areas
- the new public-private venture capital
- the recent innovation initiatives.

Finally, there are areas where Denmark (and Sweden) should learn from others, such as:

- sufficient proof-of-concept and pre-seed support (prior to start-up of new companies)
- tax incentives for young, innovative biotech companies.

8 References and related literature

Annual reports from Danish life science companies.

Bergström H. & Gergils H. (2007), *Tre stora, tre små, Biomedicin och innovationssystem i Kina, Indien, USA, Irland, Danmark och Finland*

Bloch C. (2006), *Biotechnology in Denmark 2005* Working paper 2006/04, The Danish Centre for studies in Research and Research Policy

Dahlgren H. & Valentin F. (2007), *Shaken not stirred. Multinational takeovers in Sweden's pharmaceutical industry,* Biotech Business Working Paper 04-2007, Copenhagen Business School

Danish Pharma Consortium, www.biologue.ku.dk

Dansk Biotek (2007), *Nyt fra dansk biotek*, March 2007

Dansk Biotek (2008), *Nyt fra dansk biotek*, March 2008

Dansk Industri (2008), *Indsats for forskningsinvestering misser målet*, May 2008, www.di.dk

Davis L. & Lotz P. (2006), *Academic-Business cooperations in biotechnology. Who cooperates with firms and why?* Biotech Business Working Paper 06-2006, Copenhagen Business School

DEA, Danish Business Research Academy (2008) *Tænk på tværs i forskning og uddannelse*

DeltaKultur og Kommunikation (2006) *Dansk lydteknologi-en global styrkeposition*

Ernst & Young (2007) *Beyond Borders. Global biotechnology report 2007* and Supplement *European Country Profiles p. 8*

Forskerforum (2007) *Reform: Danish "Fusion universities*", April 2007, and http://redfriforsk.blogspot.com

Globaliseringsrådet (2006) *Fremgang, formyelse og tryghed, strategi for Danmark I den globale økonomi*

Gluud C. & Nikolova D. (2007), *Likely country of origin in publications on randomised controlled trials and controlled clinical trials during the last 60 years*, Trials 8, 1-8 (www.trialsjournal.com)

Implement & COWI (2008) *Bio-sundhedsklyngen. Klinisk forskning og kliniske forsøg med lægemidler I Danmark: Analyse og anbefaling af indsatsområder*. Prepared for the Capital Region of Denmark, University

of Copenhagen and the Danish Association of the Pharmaceutical Industry (Lif), June 2008

IVA (2008) *Nationell policy for forskning och innovation: En framtidsinriktad omvärldsanalys*, IVA-M 381

IVA (2008) *Forskning och Innovation i Sverige- En internationell jämförelse*, IVA M 382

FORSK2015 (2007), Rapport *31 strategiske forskningstemaer*

Lindgaard Christensen J., Gregersen B., Johnson B., Lundvall B. & Tomlinson M. (2008), *Small country innovation systems*, Edqvist C. & Hommen L., Eds., Edward Elgar, Cheltenham, UK

Lif, the Danish Association of the Pharmaceutical Industry, www.lif.dk

Lif (2007), *Klinisk forskningsaktivitet i Lifs medlemsvirksomheder*, September 2007

Lodin, S-O. (2008), *Svenska skatter och omvärldsbeskattningen – en jämförelse mellan skatteuttaget i Sverige och fjorton viktiga omvärldsländer* (Swedbank)

MandagMorgen (2008), *Dansk klinisk forskning er under pres*, MM23 (16 June 2008), 10-12

Marks & Clerk Biotechnology Report 2007, http://www.marks-clerk.com/attorneys/news_one.aspx?newsid=135#

McKinsey (2007), *Action MedTech- Key measures for growing the medical device industry in Sweden*, p. 35

Medicon Valley Alliance, Copenhagen Capacity & Region Skåne (2007), *A Danish-Swedish Life Science Cluster*, p. 10

Medicon Valley Academy (2004), *From bioscience to new jobs in Medicon Valley*

Medicon Valley Academy & Tage Dolk Addendi (2005), *Kompletterings-PM omfattande Medicon Valley (Skåne och Själland)* till Nationella och regionala klusterprofiler (VINNOVA, 2005)

Medicoindustrien (2008), *Medtech Facts & Figures*

Nordic Innovation Centre (2004), *Innovationsboken* p.24

Paarup-Petersen N (2008), Interview with Boerge Diderichsen from Novo Nordisk + Article about Novo Nordisk, ÖI Analyse March-May, 24-27.

SOU (2008), *Åtgärdsplan för klinisk forskning* (Olle Stendahl), SOU 2008:7

THE (2008), http://www.timeshighereducation.co.uk/story.asp?storyCode=401979&sectioncode=26

Valentin F. & Lund Jensen R. (2006:1), *Effects on academia-industry collaboration of extending university property rights*, Biotech Business Working Paper 03-2006, Copenhagen Business School

Valentin F., Dahlgren H. & Lund Jensen R. (2006:2), *Structure, employment and performance in biotech firms. Comparison of Danish and Swedish drug discovery firms*, Biotech Business Working Paper 05-2006

Valentin F. & Dahlgren H. (2007:1), *Alliances of Scandinavian biotech start-ups and their effects on financial performance*, Biotech Business Working Paper 01-2007, Copenhagen Business School

Valentin F. & Lund Jensen R. (2007:2), *The imprint of founders on biotech firms* Biotech Business Working Paper; 02-2007

Valentin F., Dahlgren H. & Lund Jensen R. (2007:3), *Research strategies in science-based start-ups: Effects on performance in Danish and Swedish biotechnology*, Technology Analysis and Strategic Management 19, 303-328

Valentin F., Lund Jensen R. & Dahlgren H. (2007:4), *Hvorfor går det godt i dansk biotek? Nye forskningsresultater bidrager til at læse spillet***,** Biotech. 2007, vol.3, 5, 8-12

Valentin F., Lund Jensen R. & Dahlgren H. (2008), *How venture capital shapes emerging bioclusters- A cross country comparison*, European Planning Studies 16, 441-463

Vetenskapsrådet (2006), *Hur mycket citeras svenska publikationer*, Vetenskapsrådets rapportserie 13:2006 p.24.

Vaekstfonden (2005), *The anatomy of life science boards of directors in Medicon Valley- profiles and competencies* (Egon Zehnder International)

Vaekstfonden (2007), *Venturekapital og bioteknologi i Danmark- Perspektiver for fremtiden*

Vaekstfonden (2008), *Venturekapital i Danmark - Fokus på aktører i seed-markedet*

Wichmann Matthiessen C., Winkel Schwarz A. & Find S. (2007), *Novo, a major player in the dynamics of Greater Copenhagen. The research perspective*

VINNOVA (2005), *Nationella och regionala klusterprofiler. Företag inom bioteknik, läkemedel och medicinsk teknik i Sverige 2004*. VA 2005:2

VINNOVA (2007), *National and regional cluster profiles, Companies in biotechnology, pharmaceuticals and medical technology in Sweden 2007.* VA 2007:16

VTU (2007), *Erhvervs-PhD, et effektivt redskab for innovation og viden*

VTU (2007), *Exploring best practices in incubation in Europe and Israel*, Science Alliance, Feb. 2007

VTU (2007), *InnovationDanmark* (Handlingsplan 2007-2010)

VTU (2008), *Klinisk forskning- Baggrundsrapport vedr. et strategisk forskningsprogram*

VTU (2008), *Public Research Commercialisation Survey*

VTU (2008), *Rabat til virksomheder med ambitioner* http://fi.dk/site/forside/nyheder/pressemeddelelser/pressemeddelelser-2008/rabat-til-virksomheder-med-ambitioner

The World Bank (2008), *Doing Business 2008*

9 Appendix

9.1 Interviews

BankInvest Biomedical Venture: Thomas Tscherning (Partner)

Copenhagen Business School: Finn Valentin (Professor)

Hoejteknologifonden: Carsten Gaarn Larsen (CEO)

Novo Nordisk: Boerge Diderichsen (Vice President Corporate Research Affairs)

Novo Nordisk Foundation Center for Protein Research: Michael Sundström (CEO)

Novozymes: Per Falholt (Executive Vice President and CSO)

Santaris Pharma: Henrik Oerum (CSO), Troels Koch (Vice President, Research)

Topo Target: Peter Buhl Jensen (CEO)

Ventac Partners: Mikael Oerum, Lars Hedbys (General Partners)

VTU/Danish Agency for Science, Technology and Innovation: Kresten Olesen (Special Advisor), Mette Lerdorf (Head of Section)

Sunstone Capital: Peter Benson (Managing Partner)

9.2 Bibliometry

In the following figures, the area of the circles is proportional to the total publication volume of the organisation in the dataset and the line width is proportional to the co-authored publication volume between the players that a line links.

Figure A: Bibliometric chart demonstrating co-authorships within Medicine: Co-authorship between Denmark and other countries.

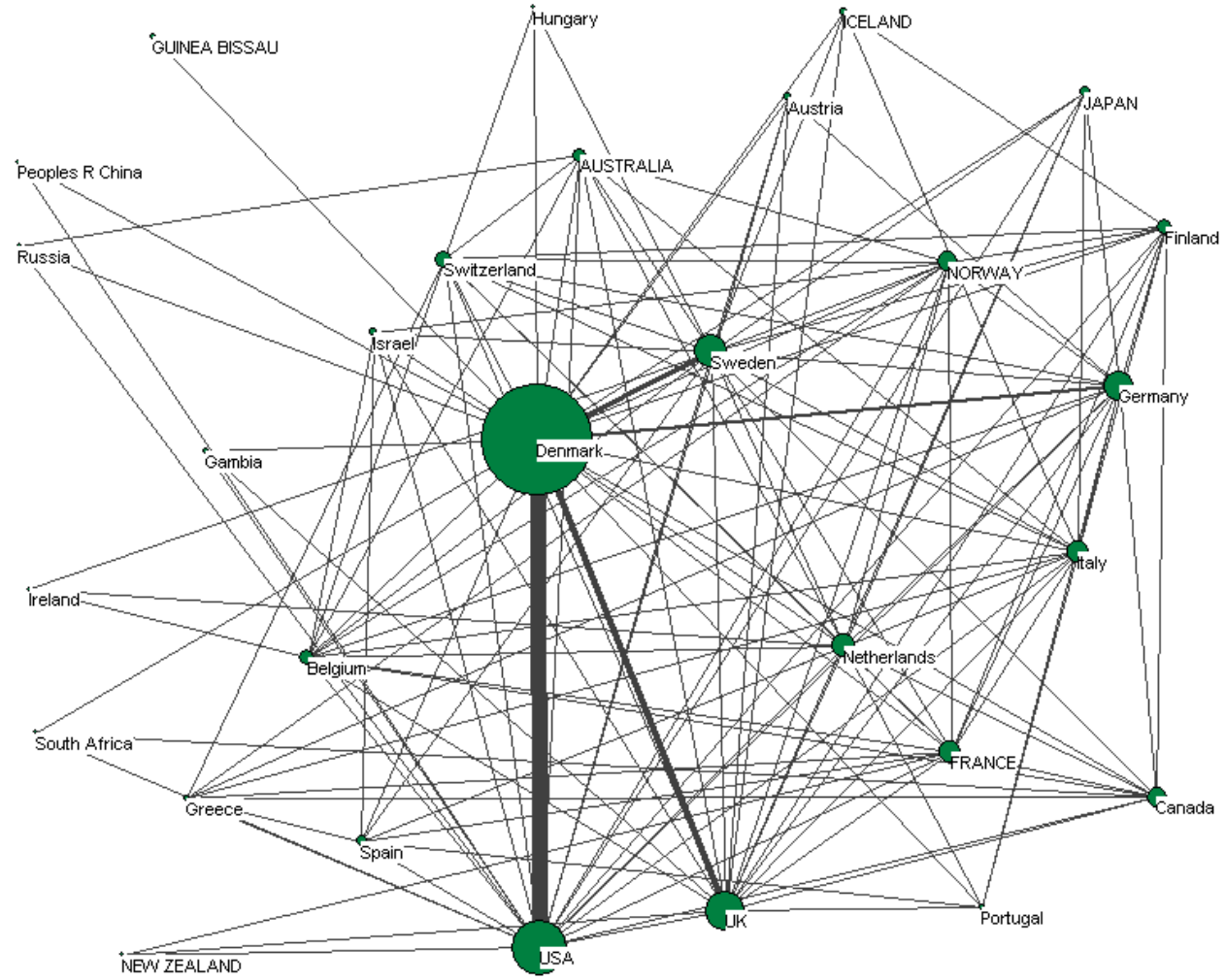


Figure B: Bibliometric chart demonstrating co-authorships within Medicine: Co-authorships between organisations

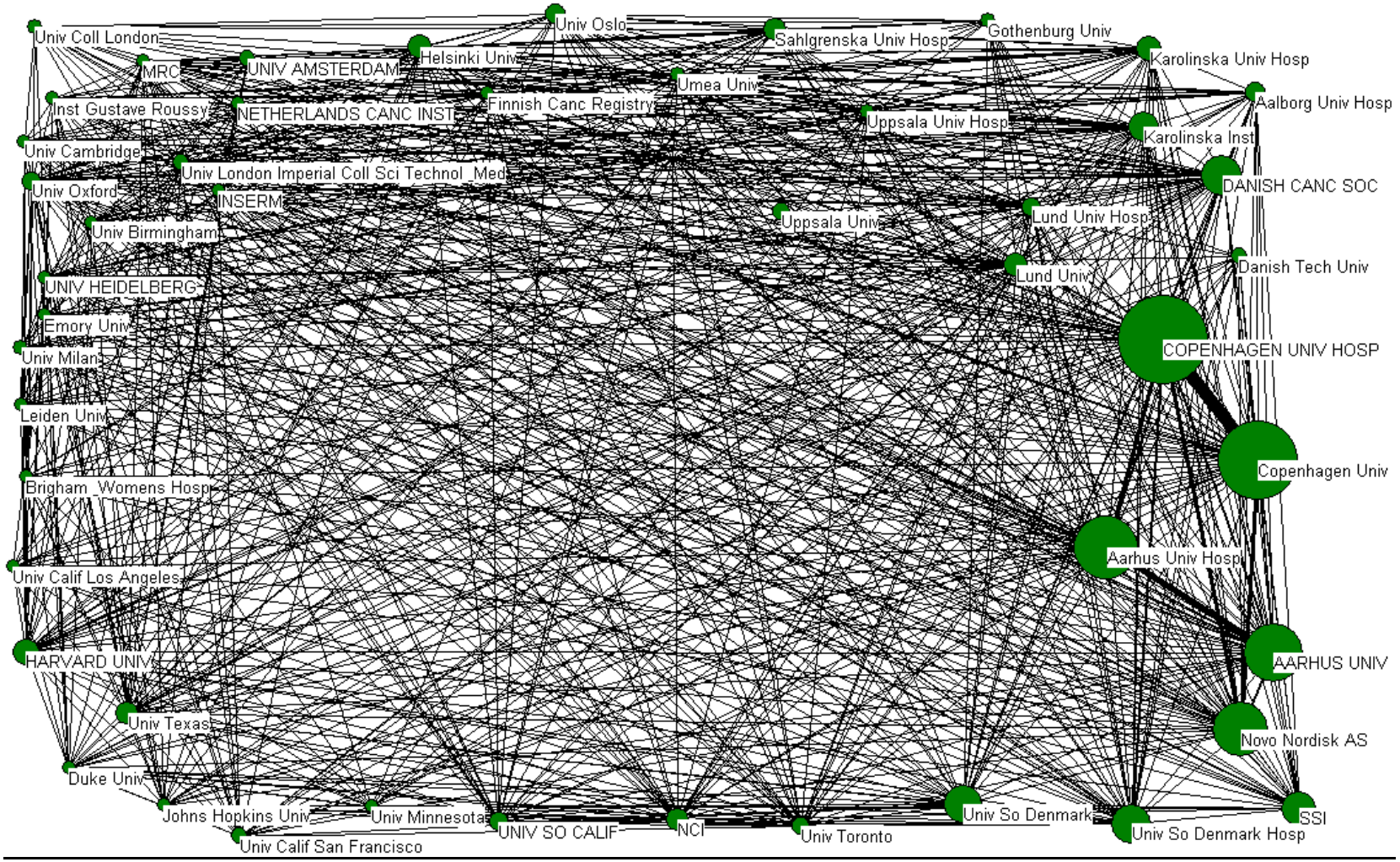


Figure C: Bibliometric chart demonstrating co-authorships within Life Science (excl. clinical medicine journals): Co-authorship between Denmark and other countries

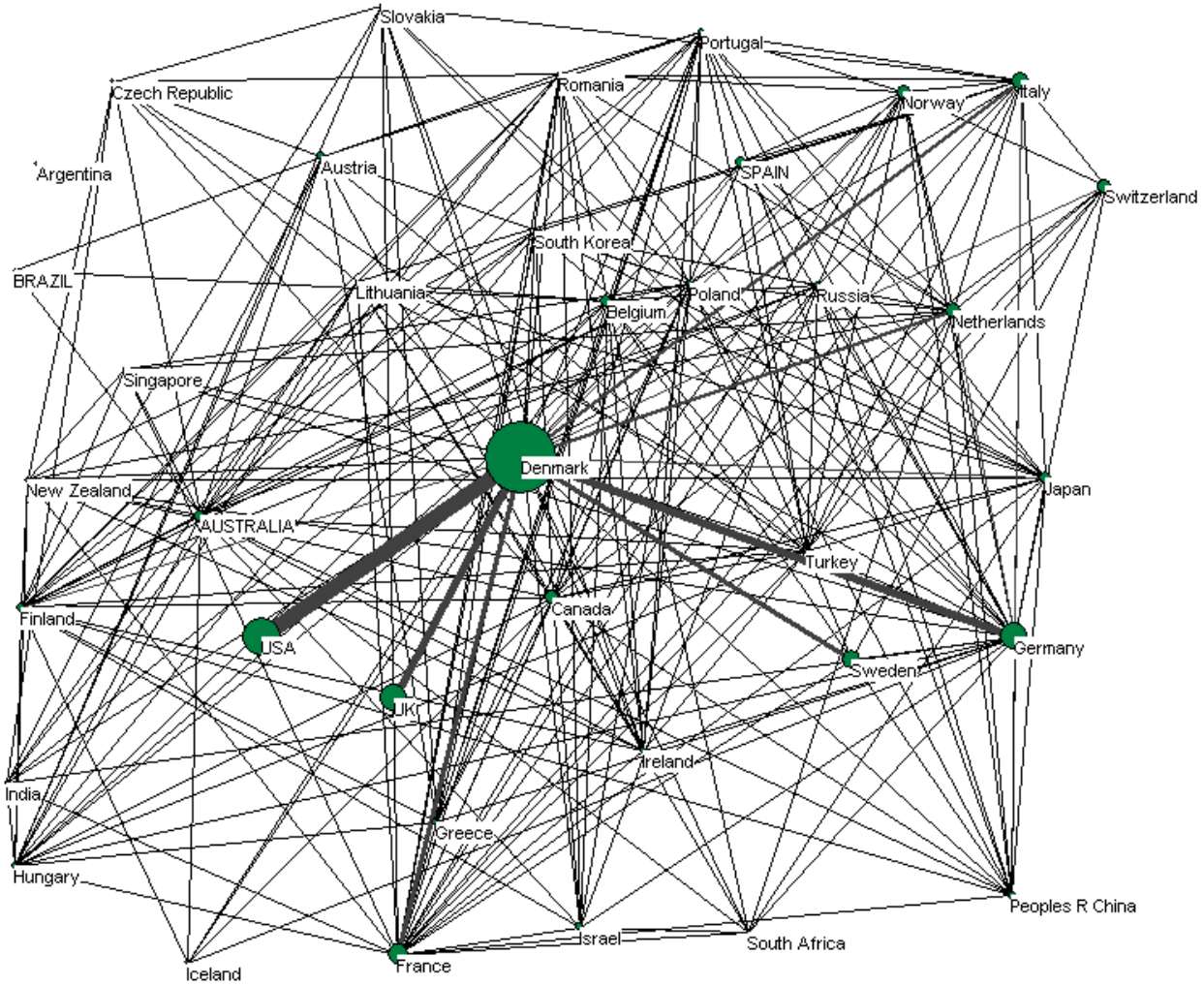
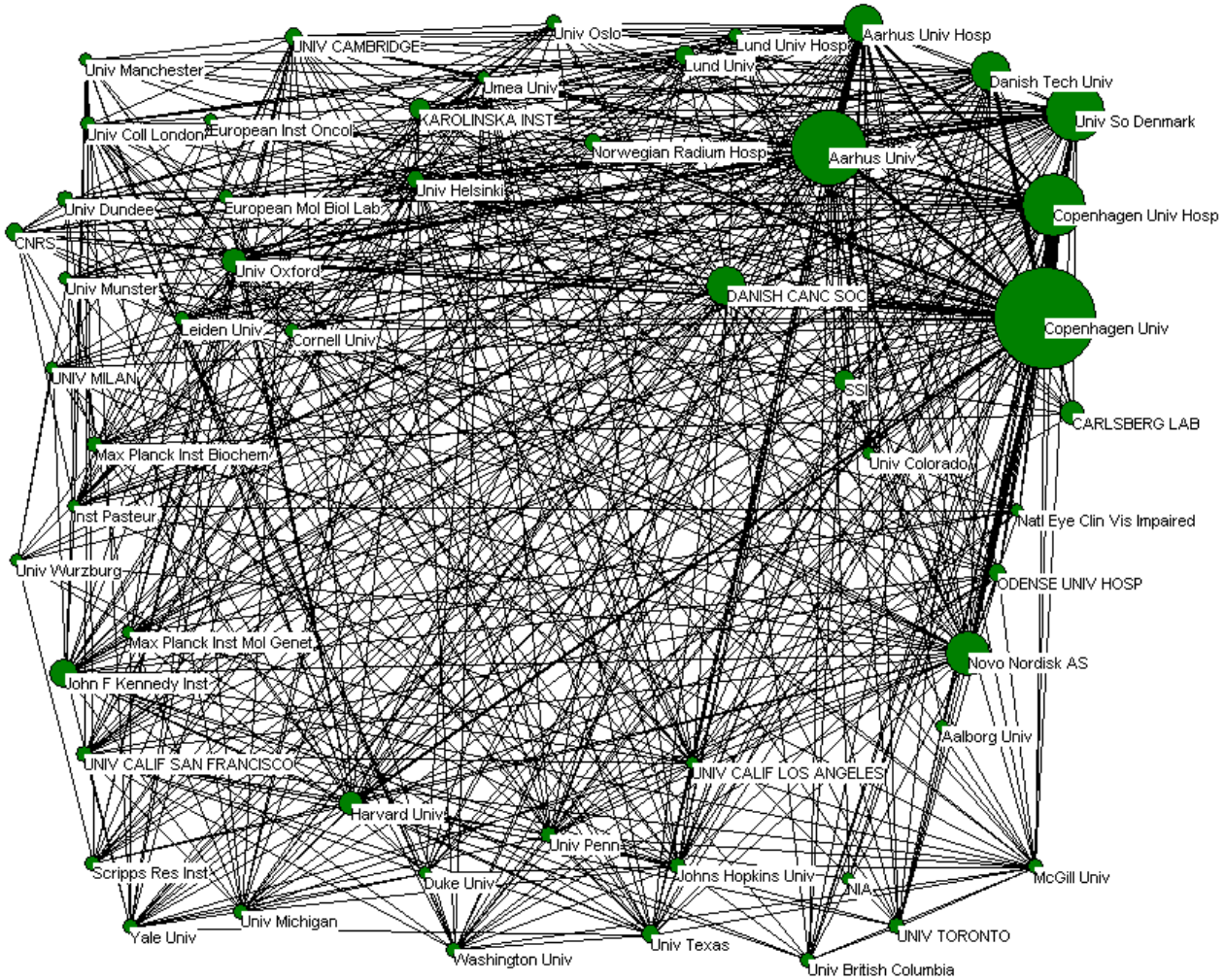


Figure D: Bibliometric chart demonstrating co-authorships within Life Science (excl. clin. Medicine journals): Co-authorships between organisations



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06 Summary - The GSM Story - Effects of Research on Swedish Mobile Telephone Developments. *Brief version of VA 2008:04, for brief version in Swedeish see VA 2008:07.*

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VINNOVA´s mission is to promote sustainable growth
by funding needs-driven research
and developing effective innovation systems

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