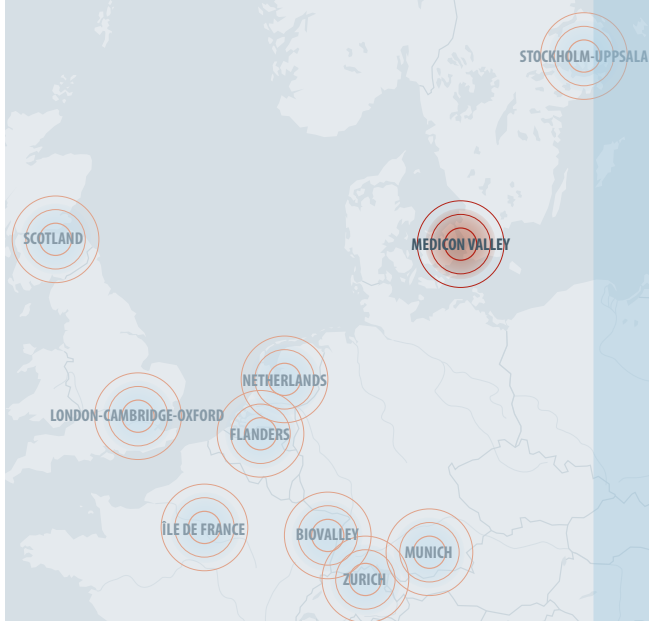


A COMPARISON OF SCIENTIFIC PUBLICATIONS IN 10 EUROPEAN LIFE SCIENCE CLUSTERS



STATE OF MEDICON VALLEY 2018

An Analysis of Life Science
in Greater Copenhagen

medicon valley **alliance**

Creating Opportunities

STATE OF MEDICON VALLEY 2018

An Analysis of Life Science in Greater Copenhagen

Commissioned and published by: Medicon Valley Alliance.
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PREFACE

Medicon Valley is in a period of transition. The life science sector has been the region's growth motor, even through the darkest years of the economic crisis. But now is no time to rest on laurels. The sector is facing new research breakthroughs in everything from personalised medicine to biopharmaceuticals and gene therapy. The dividing lines to other sectors are being dissolved with new digital solutions and artificial intelligence that in part facilitate diagnostics and in part give patients increased control over their care.

One of the most important foundations for the creation of a competitive life science cluster is the access to – and the emergence of – internationally leading university environments and research institutions. For this reason, we have commissioned a unique comparison of Europe's ten most influential life science clusters, based on scientific publication volume in the life sciences, from the Dutch research institute CWTS at Leiden University.

We're happy to report that the percentual increase in scientific publications in the life sciences is greater in Medicon Valley than in any other cluster in Europe's other Top Ten. Calculated according to the number of publications, the region's placement is firmly in the middle of the list, at the top of which is the life science cluster in London-Cambridge-Oxford.

Like the university representatives interviewed in the report, we from Medicon Valley Alliance would like to call attention to the unique opportunity offered by our Danish-Swedish border region with its strong university environments, innovative businesses and high-quality health care systems – all within a small geographic radius. This report is a way for us to highlight the importance of the life science cluster in our border region. With our network activities and joint initiatives, we wish to contribute in stimulating the transnational, trans-Øresund exchange for the benefit of industry, research and growth in Denmark and Sweden.

Copenhagen and Malmö
11 October 2018

Petter Hartman
CEO Medicon Valley Alliance





PHOTO: ZEALAND PHARMA

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PHOTO: ZEALAND PHARMA

23%

The increase in the number of scientific publications in Medicon Valley between 2006-2009 and 2013-2016, as shown by a unique comparison of ten European clusters made by the Dutch research institute CWTS at Leiden University on behalf of Medicon Valley Alliance.

The BioInnovation Institute is open

Medicon Valley's major new initiative is called the BioInnovation Institute, BII. Funded by the Novo Nordisk Foundation, with a budget of 392 million DKK, it aims to generate new companies from the life science research at the region's universities. The Institute is situated at COBIS in Copenhagen.



PHOTO: NEWS ØRESUND

BEACONS IN TRANSITION. LEO Pharma's CEO Gitte Aabo is investing in biopharmaceuticals, potentially gene therapies, and digital solutions to become a global leader in dermatology. Novo Nordisk's hope for the future – the diabetes drug Ozempic – has been approved. Ferring and Lundbeck are also in a renewal phase.

3%

The increase in employment in Medicon Valley's life science companies between 2015-2016, the most recent year for which employment statistics are available.

There are around 1 500 companies with a total of approximately 17 000 employees in the science parks in Medicon Valley that are fully or partially focused on the life sciences. Many of the science parks are expanding: among others, Medicon Village and Medeon are both building new office complexes; and DTU Science Park is scaling up with a new incubator – Futurebox.



PHOTO: NEWS ØRESUND

Increasing tax contributions in both countries

Danish life science sector's contribution through employees' income tax and corporation tax increased by 2% from 2015 to 2016, amounting to 16.3 billion DKK. The Swedish life science sectors contribution increased by 4% during the same period to 12.1 billion SEK.



PHOTO: NEWS ØRESUND

of the scientific publications in Medicon Valley resulted from international collaborations

A PERIOD OF TRANSITION FOR MEDICON VALLEY

The production of scientific publications by researchers from universities and research institutions in Medicon Valley has gone up 23% in a ten-year period. It's the highest rate of growth of all of Europe's ten largest life science clusters. Considering that Medicon Valley came in sixth among Europe's ten strongest research regions, this positive development is important to maintain and expand the region's competitive strength. These are two of many important results of the unique comparison done by CWTS at Leiden University for Medicon Valley Alliance.

Research is the foundation for future growth in the region's life science sector. Between the universities and businesses are a series of thriving and expanding science parks, and there are also three unique research institutions taking form in the region. The Novo Nordisk Foundation is making a major investment in the new, independent innovation environment BioInnovation Institute, BII, at COBIS in Copenhagen. The European Spallation Source, ESS, is currently under construction in Lund. ESS' data centre DMSC is adjacent to BII at COBIS in Copenhagen. The third environment is the materials research facility MAX IV, which is currently under development in Lund. All three are expected to be of great importance for life science research in the future, as well as for businesses' innovative strength.

The region's largest beacon businesses are already in a renewal phase, and new research findings are shaping the successful drugs of the future. Seen overall, Medicon Valley is in a transition phase, and there are challenges to, as well as opportunities for, new growth.

PHOTO: LUND BECK

In an initial snapshot of the situation for businesses in Medicon Valley, things are not looking as promising as they were previously. After a string of good years, growth rates for Danish pharmaceutical exports fell to a modest 1.25% in 2017, primarily due to a 13% drop in exports to the important pharmaceuticals market in the USA. The largest Danish life science companies cut back employee numbers in Medicon Valley by 400 people from 2016 to 2017. In 2018, Novo Nordisk announced new employee cutbacks.

But the situation is significantly brighter, as a review of the most important statistics over developments in Medicon Valley on pages 10-23 of this report shows. It appears to be more of a period of passage, where businesses are adapting to meet the new opportunities and challenges.

More patent applications and a more highly educated workforce

The number of patent applications for the life sciences submitted to the European Patent Office (EPO) by Danish businesses increased 15% to 643 between 2016 and 2017. Patent applications in Sweden increased 6% in the same period, to 355.

The proportion of highly educated employees at life science companies in Medicon Valley also rose from 33% in 2015 to 35% in 2016.

Major new investments by beacon businesses

The growing number of patent applications and the expanding proportion of the labour force that is highly educated are in line with the renewal efforts evident in Medicon Valley's largest life science companies.

LEO Pharma, which focuses on dermatological pharmaceuticals, offers a clear example of the transition. In an interview on pages 30-31, CEO Gitte Aabo talks about the company's renewal efforts.

According to the restructuring plan from 2016, the company was to decrease the number of employees by 400, but would recruit another 200 people to bring in competence for the new area of biopharmaceuticals. In September 2018 it was announced that 60 employees

would be let go, 25 of whom were in Denmark.

Since 2016, LEO Pharma has entered a contract with AstraZeneca and launched its first biopharmaceutical for the treatment of mild to severe psoriasis, Kyntheum. In March of this year, it sold a product portfolio with ten traditional pharmaceutical products to Swedish Karo Pharma for €260 million. In July, the company announced plans to acquire Bayer's global portfolio of prescription dermatology products.

The strategy "Helping Sarah - LEO towards 2025" involves a major investment in new partnerships, biopharmaceuticals, potentially gene therapy, and new digital solutions for diagnosis and improved patient

involvement. Five global trends that impact the life science sector are identified in the strategy:

- New technologies.
- Digital disruption.
- Consumer health.
- Demographic changes.
- Payer pressure.

For the diabetes giant Novo Nordisk, payer pressure on the American market has been the greatest challenge since 2016, forcing personnel cutbacks to cope with the pressure on prices in the short-term with reduced costs. The most important long-term change for Novo Nordisk is that its hope for the future – the diabetes drug Ozempic – has been approved, and is expected to be used for the treatment of other disorders in the future.

Lundbeck also has been through a series of cutbacks to bring down costs, and has now entered a phase during which the patents for old bestselling products are expiring and new products are being introduced. In an interview on pages 28-29, Ferring Pharmaceuticals' owner and chairperson Frederik Paulsen talks about how he is aiming to completely transform the company within 10 years with new research platforms and collaborations.

More research collaboration on the agenda

Not just pharmaceutical companies like LEO Pharma and Ferring are discussing the weight of more collaboration. In interviews with university representatives on pages 52-59, the desire for more joint research



"The number of patent applications in the life sciences from Danish businesses increased 15% in 2017."

efforts in Medicon Valley is incontrovertible. Some of the suggestions they make are targeted research funds for transborder collaboration and joint educational training for students to meet and get to know one another. Vice Chancellor of Malmö University Kerstin Tham suggests a common life science strategy for Medicon Valley. She believes that a strategy in e.g. diabetes could help create a strong profile for the region both nationally and internationally.

– One way to get started with a strategy in Medicon Valley for e.g. diabetes would be to hold a symposium in Brussels together with the businesses. I think it's important to start with something concrete. It's difficult for us – as the university leadership – to steer research, but we can for example organise meeting places, like a seminar in Brussels, says Kerstin Tham.

Investments in the region

Life science is on the national agendas in Denmark and Sweden. The sector is considered important for growth and employment. Both countries have

created specific life science offices as part of the ongoing national investments. There are a number of interesting new efforts in the overlap between universities and the industry. The Novo Nordisk Foundation has approved an investment worth 392 million DKK to build up the independent innovation environment BioInnovation Institute at COBIS in Copenhagen. The Institute focuses on start-ups. Medicon Valley's science parks have also begun a new expansion phase. DTU Science Park has changed its name from Scion DTU and is adding a new incubator; Medicon Village has divided its operations into two companies, separating innovation and property activities, and like Medeon, it is currently constructing a new office building. Ideon also underwent a geographic expansion a few years ago, joining forces with more real estate companies, and COBIS is now completely leased.

There are high hopes in the region's life science sector for the new research facilities European Spallation Source, ESS, and MAX IV in Lund.

LIFE SCIENCE DEFINITION

Life science can be defined as the study of living organisms (including microorganisms, plants, animals and human beings), but when descri-

bing a life science cluster, life science is perceived in a broader context. It includes the pharmaceutical, biotechnology and medical techno-

logy industries, as well as the academic institutions conducting research within life science and hospitals treating patients in the clinic.



Frederik Paulsen,
owner, Ferring.



Lund University.



Thomas Nagy,
CEO BioInnovation
Institute.



University of
Copenhagen.



Kerstin Tham,
Vice-Chancellor
Malmö University



Medicon Village
in Lund.

FACTS AND FIGURES: Moderate growth in Medicon Valley

PHOTO: LUNDBECK

Medicon Valley still holds its position as Scandinavia's leading life science region, even if the growth rate in 2017 appears somewhat subdued compared to previous years. A moderate increase of 1.25% in Danish life science exports and figures from the largest Danish life science companies in Medicon Valley for 2017 that show a drop in the number of employees indicate that life science companies in Medicon Valley took their foot off the gas in 2017. Although, recent positive announcements suggest that the pace will pick up again in 2018-2019, continued pressure on pricing from the American market will present challenges for certain parts of the sector as illustrated by the recent Novo Nordisk restructuring and lay-offs.

- The most recent year for which employment statistics are available – 2016 – shows a continued growth path for Medicon Valley's life science companies with an increase of 3%. In the period for which figures are available – 2008-2016 – this strong increase in the number of employees was only surpassed by the increase in 2015.
- A steadily growing number of these new jobs are being filled by highly educated employees, and the percentage of highly educated employees at the life science companies in Medicon Valley increased in 2016, going from 33% in 2015 to 35% in 2016.
- In the Stockholm-Uppsala region, life science companies also hired more employees in 2016, resulting in an increase of 2.2%. This is the first time since 2008 that the life science companies in and around the Swedish capital have increased their workforce, after a period between 2008-2015 in which life science companies lost approximately one in five jobs.
- Medicon Valley employed a total of 58% of those working in the Danish and Swedish life science sectors in 2016, and the Stockholm-Uppsala region employed 21%.

MEDICON VALLEY: RAPID GROWTH IN 2016, FOLLOWED BY DECELERATION IN 2017

In Medicon Valley, the development tendency toward increased employment on the Danish side and decreased employment on the Swedish side continued in 2016; in Skåne, there was a 1.5% drop in employment in the life sciences in 2016. In Skåne, a total of 32% of the positions in life science have been eliminated since 2008; the closure of Astra Zeneca in Lund is the primary explanation. The Capital Region of Denmark dominates the life science industry in Medicon Valley, accounting for three out of four jobs, and it strengthened its position during 2016.

Figures from the largest Danish life science companies in Medicon Valley, which account for 60% of the employment in the Danish part of Medicon Valley, show a decrease of 400 employees in 2017. The decline is explained by cutbacks at Novo Nordisk; in September 2016, the company announced that it would be cutting 1 000 jobs

due to pressure on prices in the USA. 500 of these were in Denmark. The restructuring plan at LEO Pharma – which was announced in 2016, would mean the dismissal of a total of 400 employees but also create 200 new positions – is not reflected in the figures for the number of employees in 2017, which instead show a slight increase in the number

of employees. This can be explained by the fact that 2017 was a record year for the Danish life science company with its headquarters in Ballerup; it was the first time that the company's turnover topped 10 billion DKK. New product sales were better than expected: Kyntheum®, LEO Pharma's first biologic for the treatment of mild to severe psoriasis, was launched in Europe in 2017, and sales of this and of the combination drug for psoriasis treatment Enstilar® surpassed expectations.

News from the life science companies in Medicon Valley in 2018 thus far indicate renewed success for the life science sector in Medicon Valley in 2018 and 2019, but there are also challenges, for example pressure on prices on the American market:

- In May 2018, the U.S. Food and Drug Administration (FDA) granted drug designation to Bavarian Nordic's new cancer vaccine BN-Brachyury for the treatment of the rare sarcoma chordoma orphan. Bavarian Nordic is in an expansion phase after having entered into a contract with the US Department of Health in 2017 to deliver its freeze-dried smallpox vaccine IMVAMUNE. The company is investing in a fill-finish manufacturing line at its facility in Denmark to increase production capacities. To do this, it was granted a €30 million loan from the European Investment Bank in August 2018. The facility is currently under construction, and should be operational in 2021.

- Lundbeck's results for the first half of 2018 surpassed expectations, but the second half of the year will bring a lower yield, as patents will expire for a number of the company's products.

- In August of 2018, LEO Pharma announced that it has acquired a number of drugs to treat dermatological disorders from German Bayer. As part of the transaction, 450 Bayer employees will join LEO Pharma. Sales of prescription dermatological drugs brought in around 2.1 billion DKK in 2017.

- In 2017, the American FDA approved Novo Nordisk's Ozempic®, a once-weekly semaglutide, as a GLP-1 drug to treat type 2 diabetes while reducing weight, and in 2018 the product was approved by the European Medicines Agency. Novo Nordisk has also acquired the British biotech company Ziylo Ltd to accelerate its development of glucose responsive insulin.

- The hearing aid company Widex announced in May 2018 that it will merge with one of its competitors: the German Sivantos, formerly known as Siemens Audiology, making the new company the

third largest hearing aid company in the world. Sivantos' headquarters are in Singapore. Following the merger, the company's headquarters operations will be placed in Singapore and in Lynge (Denmark), where Widex's headquarters are located.

- The pharmaceutical company Ferring's new residence, Soundport, which is being built close to Copenhagen Airport in Kastrup, should be completed in 2020. There will be space for 750 employees there; i.e. about 50% more than in the current facilities in Neroport, Ørestad.

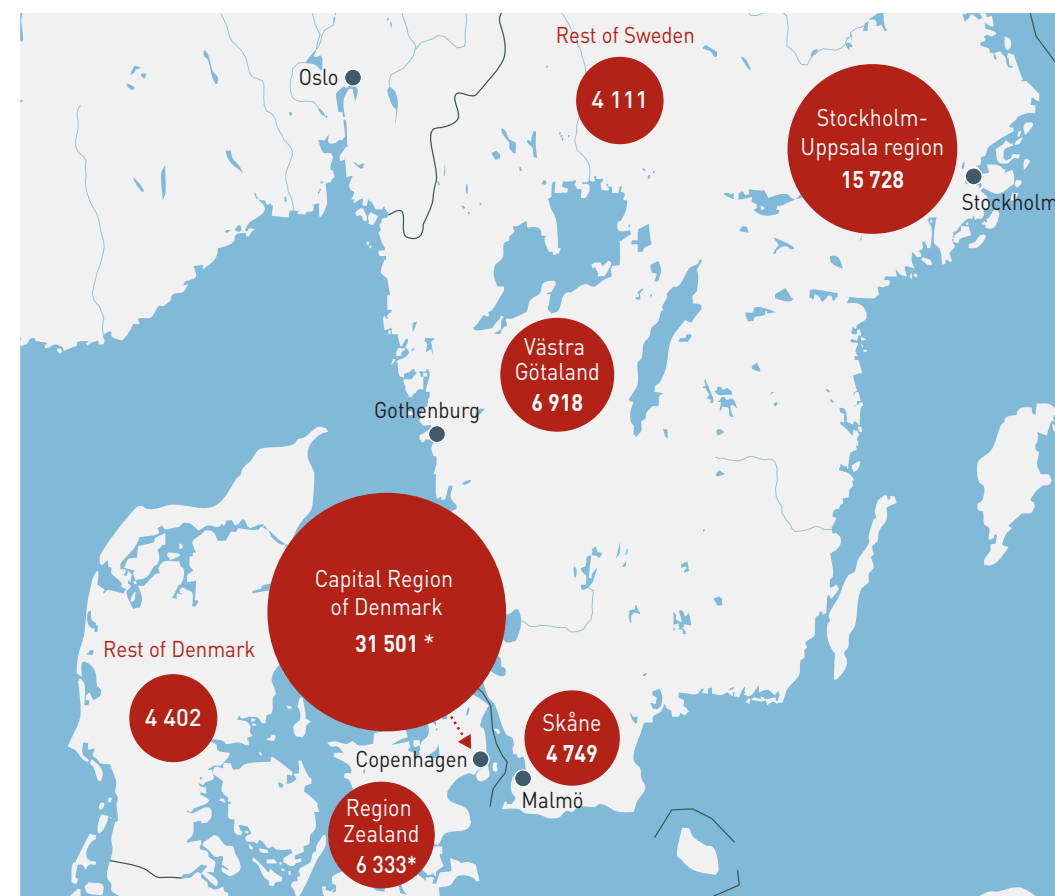
- Novo Nordisk expects the pricing pressure on the American market to continue through 2019. In its half-year report for 2018, the company stated that prognoses for 2019 indicate average prices after rebates will be lower than in 2018. To cope with the increased pressure from American pharmaceutical procurement services to increase rebates, Novo Nordisk has raised the price of its insulin product Tresiba twice in 2018. Despite the raised price, the operating profit from the American market dropped 10% in the first half of 2018 (in DKK). These challenges have definitely influenced the September 2018 reorganisation of part of Novo Nordisk in Denmark and the resulting lay-offs of about 400 employees.



68%

The pharmaceutical industry is dominant in the life science industry in Medicon Valley, employing 68% of those working in the life science industry, whilst medtech companies provide employment for 17%, and 16% are employed in wholesale trade businesses.

EMPLOYMENT BY REGION IN DENMARK AND SWEDEN



Source: Statistics Denmark, Statistics Sweden and information from the biggest life science companies in Denmark.

EMPLOYMENT AND CHANGE OVER TIME*

	2016	Change 2015-16	Annual change 2008-16
Denmark	42 236	3.9%	1.7%
Capital Region of Denmark	31 501	3.5%	2.1%
Region Zealand	6 333	4.0%	1.1%
Denmark, rest of	4 402	6.4%	0.2%
Sweden	31 506	0.9%	-2.2%
Skåne	4 749	-1.5%	-4.6%
Stockholm-Uppsala region	15 728	2.2%	-2.3%
Västra Götaland	6 918	-0.1%	0.5%
Sweden, rest of	4 111	0.7%	-2.6%
Medicon Valley	42 583	3.0%	1.0%

Source: Statistics Sweden, Statistics Denmark and information from the biggest life science companies. * The figures from Statistics Denmark have been adjusted due to a systematic review of the employment figures for all of the Danish municipalities in Medicon Valley. The figures have been corrected to take two types of sources of error into account: 1) Companies that have changed their industrial classification code to life science during the period 2008-2016 have been included in the entire period; 2) Life science companies with a non-life science industrial classification code have been included (for instance Novozymes). As a result, the figures from last year's report cannot be compared directly with this year's figures.

Eight municipalities account for three-fourths of employment

The life science sector in Medicon Valley is concentrated in a few municipalities in and around the biggest cities. Eight of the total 79 municipalities in the Greater Copenhagen region provide employment for three-fourths of those employed in the life science industry in Medicon Valley. On the Danish side, the five largest municipalities for life science companies are Gladsaxe, Ballerup, Copenhagen, Kalundborg, and Hillerød; on the Swedish side, the three largest municipalities are Malmö, Lund, and Helsingborg. Today, Malmö is a larger city for pharmaceuticals than Lund as regards the number of employees at life science companies, but Lund is the epicentre of life science research in Skåne. With university research, Ideon Science Park, Medicon Village, the research facilities MAX IV and the still in-progress ESS, Lund is indisputably the centre of life science research in Skåne, but with regard to the number of employees in life science companies, Lund has faced difficulties over the past decade.

The shift to a more highly educated workforce

In Denmark as in Sweden, highly educated employees or those with research training make up a larger share of those employed in the sector in 2016 than they did in 2008. This development is particularly apparent in Sweden, where 92% of the positions that disappeared from the life science sector from 2008–2016 are those generally sought by employees with a lower level of education, while only 8% of the positions are competed for by highly educated applicants. In Denmark, 82% of the positions created in the life science sector from 2008–2016 were competed for by people with a high level of education, and a mere 18% more jobs were created for people with a lower level of education.

The larger percentage of highly educated people in the life science industry can be explained by the fact that many manufacturing positions have been moved abroad, whilst companies have concentrated their Nordic activities on research and development.



PHOTO: NEWS ØRESUND

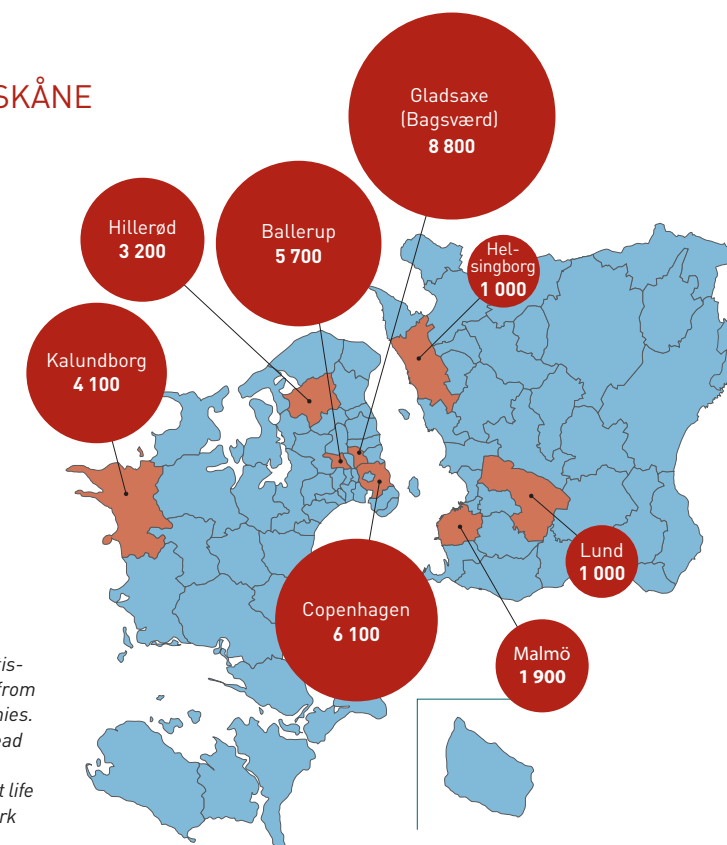
The percentage of highly educated employees in Medicon Valley is still rising

The number of highly educated employees at life science companies in Medicon Valley has continued to increase in relation to the total number of employees in 2016, growing from a share of 33% in 2015 to 35% in 2016. While the picture is the same in all three regions of Medicon Valley, the pace with which the share of highly educated employees is rising differs between the three regions.

In the Capital Region of Denmark, the percentage of highly educated employees in the workforce is increasing much more rapidly than in Region Sjælland and Region Skåne, rising from 37% to 39% in 2016. In the same period, the percentage of highly educated employees in Region Sjælland rose from 15% to 16%, and in Region Skåne from 34% to 35%. The composition of employees at the life science companies in Region Sjælland reflects the large production facility in Kalundborg; the percentage of highly qualified employees is thus lower in Region Sjælland than in Medicon Valley's two other regions.

Increased employment in the life science industry in the Danish part of Medicon Valley has given more jobs to the highly educated than to those with other levels of education. Here, eight out of ten new jobs went to people with a higher level of training from 2008–2016. In Skåne, where the number of employees in life science companies fell 32% from 2008 to 2016, the drop did not hit those with a higher education quite as hard. Only one out of four jobs that were eliminated were held by a highly educated employee.

EMPLOYMENT IN LIFE SCIENCE IN SKÅNE AND ZEALAND BY MUNICIPALITY*



Source: Statistics Sweden, Statistics Denmark and information from the biggest life science companies. For more information please read the note on page 13.

* The map shows the five biggest life science municipalities in Denmark and the three biggest in Skåne.

Some examples of companies in the largest life science municipalities

Gladsaxe: 8 800 employees

Headquarters and large facilities for Novo Nordisk (6 300 employees) and its subsidiary Novozymes (2 000 employees).

Ballerup: 5 700 employees

Novo Nordisk (2 400 employees), LEO Pharma (2 000 employees at headquarters and production site), GN Hearing, Symphogen and Pfizer are all based in Ballerup Municipality.

Copenhagen: 6 100 employees

H. Lundbeck (1 500 employees at headquarters and factory), Ferring Pharmaceuticals (560 employees at research facility). The Danish capital is also the location of Xelia Pharmaceuticals, Genmab and several foreign life science companies such as Novartis, Boehringer Ingelheim, Stryker and AstraZeneca.

Kalundborg: 4 100 employees

Novo Nordisk (3 500 employees at production site), Novozymes (600 employees at production site)

Hillerød: 3 200 employees

Novo Nordisk (2 200 employees), Biogen (around 600 employees at production site), PolyPeptide and Zymenex.

Malmö: 1 900 employees

Rechon Life Science, PolyPeptide Group, Nordic Drugs, Qpharma and Eurodiagnostica and numerous national and regional headquarters from the life science sector, e.g. Lundbeck, LEO Pharma and Novo Nordisk.

Lund: 1 000 employees

Lund's life science environs are dominated by the medtech company Baxter (Gambro Lundia; around 720 employees), which is an important manufacturer of e.g. dialysis equipment.

Helsingborg: 1 000 employees

McNeil, which develops and manufactures quit smoking products under the brand name NICORETTE®, is the largest life science company in Helsingborg (around 650 employees).

THE GROWTH RATE IS SLOWING DOWN IN DANISH LIFE SCIENCE, BUT PICKING UP AGAIN IN SWEDISH LIFE SCIENCE

With an increase in life science export of just 1.25% in 2017, Danish life science companies saw the lowest increase since 2007. Swedish life science companies however returned to their growth path, with an increase of 6.1% in life science exports measured in national currency. Both countries lost some of their holdings on the important American market and increased their holdings on the second largest global market, China.

The strong growth path for Danish life science exports (pharmaceuticals and medtech) was replaced with a more modest growth rate of 1.25% measured in DKK in 2017. Life science exports to the USA, which is by far the largest export market for Danish life science companies, decreased 13% in 2017, while the Danish life science companies gained market shares on their second largest export market in China, with an increase in life science exports of 16%. Danish life science companies also increased their exports to the British, Italian and Canadian markets.

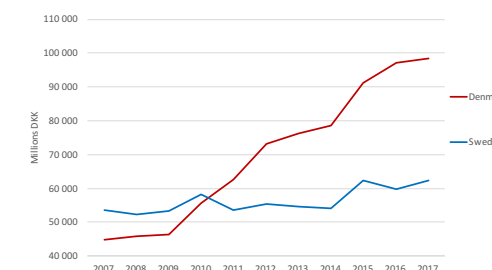
Swedish life science companies gathered new strength in 2017, increasing life science exports

6.1% measured in SEK, and they seem to have overcome the difficulties presented in recent years by mergers, cutbacks, and the closure of large research and production facilities. There was a notable success on the second largest export market for the Swedish life science companies – the Chinese market – where life science exports increased by 45%. Swedish life science exports totalled 62 billion DKK in 2017. Swedish life science companies also saw significant increases in their exports to Japan, Russia and Australia in 2017, while life science exports to Denmark and the US dropped 14% and 4%, respectively.

The Swedish life science sector recruited more people than it dismissed in 2016, and the number

of employees grew 0.9%, according to figures from the register-based labour market statistics (RAMS) from Statistics Sweden. 2016 may thus be seen as a new turning point for the Swedish life science industry, as it is the first year in the period for which we have figures in this report (2008-2016) that shows positive growth in the number of employees. The growing number of employees in the Swedish life science sector is concentrated in the Stockholm-Uppsala region with a 2.2% increase in the number of employees, and parts of Sweden outside of the major cities, while the number of employees in life science companies in the Västra Götaland region remained unchanged

VALUE OF EXPORTS, IN MILLIONS (DKK)



Figures are for medical and pharmaceutical products and medical instruments, apparatuses etc.
Source: Statistics Denmark and SCB/Statistics Sweden.

THE PRINCIPAL EXPORT MARKETS FOR DANISH LIFE SCIENCE

	Exports in millions (DKK) 2017	Annual growth 08-17
USA	22 964	14%
China	8 640	26%
Germany	6 346	5%
Sweden	5 009	3%
Japan	4 705	7%
Great Britain	3 915	7%
Italy	2 838	8%
France and Monaco	2 786	-1%
Norway	2 698	11%
Spain	2 264	8%

Source: Statistics Denmark

THE PRINCIPAL EXPORT MARKETS FOR SWEDISH LIFE SCIENCE

	Exports in millions (DKK) 2017	Annual growth 08-17
Germany	8 012	3%
China	7 882	30%
USA	7 289	-1%
Japan	4 300	23%
Norway	3 220	1%
France	3 086	-5%
Australia	2 980	4%
Great Britain and Northern Ireland	2 113	-2%
Belgium	1 995	-7%
Finland	1 683	-3%

Source: SCB/Statistics Sweden and Riksbanken.
* Annual growth is calculated on figures in national currency.

EXPORTS OF PHARMACEUTICALS AND MEDTECH PER CAPITA, 2017

Denmark is the world's fourth largest exporter of pharmaceuticals and medtech measured in export per capita during 2017, while Sweden holds eleventh place on the global list.

Country	Export per capita, USD	Percentage of global life science export	Country	Export per capita, USD	Percentage of global life science export
Ireland	9454	6.8%	Sweden	919	1.4%
Switzerland	9243	11.6%	Israel	877	1.1%
Belgium	4638	7.8%	Hungary	604	0.9%
Denmark	2586	2.2%	United Kingdom	542	5.3%
Malta	2155	0.1%	France	521	5.2%
Netherlands	1941	4.9%	Italy	482	4.3%
Singapore	1884	1.6%	Costa Rica	437	0.3%
Slovenia	1415	0.4%	Panama	407	0.2%
Germany	1191	14.6%	Lithuania	371	0.2%
Austria	1125	1.5%	Finland	370	0.3%

Source: UN Comtrade Database, World Bank and Danmarks Nationalbank.

2017 was a boom year for life science exports to China:

Sweden 45%
Denmark 16%

Both Sweden and Denmark lost some of their holdings on the important American market and increased their holdings on the second largest global market, China.

Overseas production not included in statistics

Export statistics do not present a complete picture of the success of the Danish and Swedish life science companies; as in many other sectors, manufacturing is increasingly being established in various local markets and is thereby not encompassed by export statistics. According to Statistics Denmark, in 2015 Danish manufacturing companies sold goods abroad that were not produced in Denmark for the amount of 120 billion DKK – an increase of 112 billion DKK in the 10-year period from 2005 to 2015.



PHOTO: NEWS ØRESUND

Global forecast

According to the BMI Research forecast, the global market for pharmaceuticals will be a 1.2 trillion USD industry (invoice prices) in 2018, and it is expected to continue its growth path in the forecast period of the next three years; however, the growth is expected to be lower than the growth in the global GDP, lowering the share of GDP from pharmaceutical sales.

On the American market, which is the largest pharmaceuticals market, real net per capita spending has declined annually from 2016 to 2018 and is expected to remain almost unchanged at almost 800 USD (2009 prices) in the coming years. China is expected to grow at a slower pace than previously with an annual growth rate of 5-8% over the next five years to reach 145-175 billion USD in 2022, according to the IQVIA Institute. China comprises more than 40% of the pharmerging markets. Together, they are projected to grow by 6-9% to 345-375 billion USD by 2022. As defined by the IQVIA Institute, pharmerging markets are countries with a per capita income below 30 000 USD and a five-year aggregate pharmaceutical growth over 1 billion USD. In other words, they are countries with unmet medical needs and growing health systems.

Companies from abroad set up in Medicon Valley

Medicon Valley's strong position in Scandinavia helps attract life science companies from abroad to the region. The Chinese drug company Zhejiang Jiuzhou Pharmaceuticals is establishing its European headquarters in Hørsholm under the name Raybow Pharma. The second-largest pharmaceutical company in Japan, Daiichi Sankyo, will open its Nordic headquarters in Copenhagen, and Nomeco is opening its Health-Care Logistics warehouse in Køge. The warehouse is the largest and most highly automated of its kind in Northern Europe, and it will supply distributors in Scandinavia, the Baltic countries and more with pharmaceuticals and other products. The investment is the Phoenix Group's largest individual logistics investment to date.

from 2015 to 2016, and continued to decrease in Skåne (-1.5%).

Although the Swedish life science sector shows positive employment growth figures for 2016, the growth in the number of employees is more modest than in the Danish life science sector, which holds its position as the strongest Scandinavian life science sector. The number of employees in the Danish life science sector continued to grow in 2016, increasing by 3.9% – almost as much as in 2015, which showed the highest growth rate in the period for which we have figures in this report (2008–2016). This is according to the latest figures from the register-based labour market statistics (RAS) from Statistics Denmark, as well as figures from the largest life science companies themselves.

A total of 31 500 people were employed in Swedish life science companies, while Danish life science companies employed 42 200 people in 2016. Furthermore, there are 1 600 employees at biotech research companies in Denmark and 1 200 in Sweden, and an additional 12 900 people in Denmark and 14 800 in Sweden work at companies that conduct scientific research. Employment improvements in the Danish life science industry are also apparent from the sector's contributions to the treasury.

Income tax paid by the employees at Danish life science companies increased by 7% in 2016, which is more than twice as much as the total increase in income tax payments, which rose 3% in 2016. In total, the income tax paid by employees at Danish life science companies amounted to 9 billion DKK in 2016, which corresponds to 1.8% of the total Danish income tax. More than 90% of all income tax paid by employees at Danish life science companies is paid by employees at life science companies in the Danish part of Medicon Valley (Zealand and the surrounding islands). The other direct contributions from life science companies to the Treasury, via corporation tax, dropped in 2016 for the second year in a row. In total, Danish life science companies paid 7.3 billion DKK in corporation tax in 2016; that is 3% less than in 2015, but 2.5 times as much as in 2008. In total, the Danish life science sector's contribution to the Danish treasury in direct tax contributions through employees' income tax and corporation tax increased by 2% from 2015 to 2016, amounting to 16.3 billion DKK in 2016.

An employment improvement of 0.9% in the Swedish life science industry in 2016 meant increased tax revenue for the Swedish state and the Swedish

municipalities as well. The total income tax for life science employees rose 4% in 2016, which is the highest increase in the period for which statistics are available (2008-2016). The increase reflects employment improvements in the Swedish life science companies, but the primary cause is an increase in the average income per employee. Employees at life science companies in the Swedish part of Medicon Valley, Skåne, are responsible for 14% of all income tax collected from employees in the Swedish life science sector, while employees at life science companies in the Stockholm-Uppsala region are responsible for around half (47%) of the income tax contributions, which correlates to the geographic distribution of employees in the country. The Swedish life science sector contributed a total of 1.9% of the total amount of income tax in Sweden in 2016, which is a little higher than in 2015 (1.8%), but still significantly lower than the 2.4% of 2008. Increasing tax payments, both in the form of income tax and corporation tax from the Swedish life science companies, are yet another indication of a turnaround of the economic trends that the Swedish life science sector have experienced in recent years. Corporation tax from Swedish life science companies increased 5% in 2016 and totalled 5.2 billion SEK. It is the second year in a row that corporation tax payments from the life science industry have increased. The sector's corporation tax contributions are however still 30% lower than they were at their height in 2011, when Swedish life science companies paid a total of 7.5 billion SEK in corporate taxes. Swedish life science companies' share of the total Swedish corporation tax was 3.8% in 2016. The Swedish life science sector directly contributed 12.1 billion SEK through income tax for employees and corporation tax in 2016, which is an increase of 4% compared with 2015.

Since the financial crisis, life science has become increasingly important for the Danish economy and less important for the Swedish economy

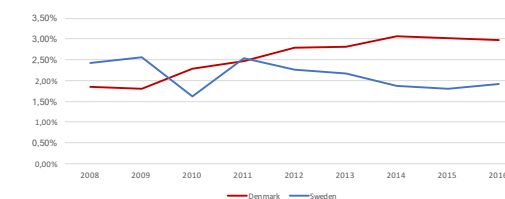
Danish life science companies have strengthened their role as growth engines for the Danish economy during the past decade. They have augmented their workforce with a total of 5 500 employees in the period after the financial crisis in 2008 up to 2016, and increased their share of the total exports from 8% in 2008 to 15% in 2016. In 2017 however, life science exports' share of the total exports decreased 0.5 percentage point. Exports of life science products accounted for a total of 98 billion DKK, and they

have more than doubled in the period 2008–2017.

In the period 2008-2016, the Swedish life science industry lost one in six jobs (-16%) and went from employing 3% more people than the Danish life science industry in 2008 to employing 25% fewer in 2016. The industry's share of the total Swedish exports fluctuated between 5% and 8% during the past decade, and was 6% in 2017.

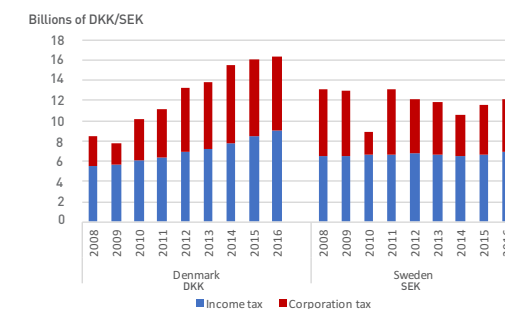
The importance of the Danish life science sector for Denmark's economy is reflected not only in employment statistics, but also in the sector's contribution to the public coffers. In the period 2008-2016, the sector financed 10% of the increase in tax revenue to the Treasury from corporation- and income tax. On average, the sector has generated about one billion more annually in the form of corporation and income tax for employees for the public coffers than the preceding year. From 2012, the rising tax

THE LIFE SCIENCE SECTOR'S SHARE OF THE TOTAL INCOME AND CORPORATION TAXES



Source: Statistics Denmark, the Swedish Tax Agency and Statistics Sweden

THE LIFE SCIENCE SECTOR'S CONTRIBUTION OF INCOME AND CORPORATION TAX



Source: Statistics Denmark, the Swedish Tax Agency and Statistics Sweden

TAX CONTRIBUTIONS IN LIFE SCIENCE

DENMARK

Income tax:

9 billion DKK

Corporation tax:

7.3 billion DKK

Income and corporation tax:

16.3 billion DKK

SWEDEN

Income tax:

6.9 billion SEK

Corporation tax:

5.2 billion SEK

Income and corporation tax:

12.1 billion SEK

The figures are for the most recent available statistics, i.e. 2016.
Source: Statistics Denmark, the Swedish Tax Agency and Statistics Sweden

Corporation tax is reported in the part of the country where the company headquarters are located; thus, figures for corporation tax on a regional level would be misleading and will not be presented. Regarding income tax, the respective figures for the Swedish and Danish parts of Medicon Valley are presented separately, because there are significant differences in the Swedish and Danish parts of Medicon Valley, with a higher income tax rate in Denmark than in Sweden due to the absence of general pay-roll tax in Denmark.

Corporation tax only on a national level

Corporation tax is charged on the company level. Since a business may have offices and production facilities in other parts of the country than where their headquarters are located, figures showing a regional distribution of corporation tax may be misleading. Income tax, on the other hand, can be analysed on a regional level, based on the region in which the income was earned. Thus, this section only presents regional figures for income tax. As income is analysed according to workplace region, border commuters from Sweden and other employees residing abroad are also included in the assessment.

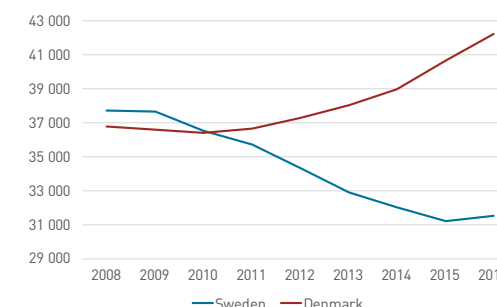
Danish and Swedish taxation procedures

Financing of public expenditures and pension differs significantly in Denmark and Sweden. The most obvious difference is that there are no employer contributions in Denmark. In Sweden,

the social security system is financed through employer contributions as a share of the employee's gross pay. Employer contributions and thus the respective taxpayer's contribution to the collective financing of the social security system are not visible on the payslip. This differs from the Danish payslip, since the social security system is financed by taxes. Employer contributions and financing for the social security system are not part of the income tax statement for people who live and pay taxes in Sweden, whilst the financing of Danish social security is part of the income tax. As pension is primarily financed through employer contributions in Sweden, and not, as in Denmark, primarily through individual's payments external to the taxation system, employer contributions are not included in the figures presented here. When comparing the Danish and Swedish tax figures you should take into account that a larger portion of total public expenditures are financed by taxes and duties in Denmark than in Sweden. Consequently, the Danish tax figures would be slightly higher even with a similar corporate tax and income tax base.

payments from the Danish life science sector were primarily due to increasing income tax payments, whilst a great increase in the sector's corporation tax from 2008 and 2012 was the primary boost for the sector's contributions to the Treasury. Part of the reason for the higher income tax contributions from the life science sector is, naturally, that employment numbers in the sector have increased, but the average income in the sector has also increased. The average income tax per employee in Danish life science companies increased by 4% annually in the period

LIFE SCIENCE EMPLOYMENT



Source: Statistics Sweden, Statistics Denmark and information from the biggest life science companies

2011-2016 – the greatest increase was 7.6% in 2012.

The sector's growing importance for the Danish economy is clearly discernible when one looks at corporation tax payments. Danish life science companies were the source of 12.1% of the total corporation tax collected from Danish companies in 2016, and viewed over a number of consecutive years, the importance of the sector has grown. In 2008, Denmark's life science companies were the source of 6.3% of the total corporation tax; in 2014, the Danish life science sector's share of all Danish companies' corporation tax contributions topped at 13.8%. However, two years of drops in corporation tax have decreased the Danish life science sector's share of the total contributions via corporation tax from Danish companies to 12.1% in 2016.

Not so in Sweden; tax contributions by the Swedish life science sector dropped by a total of around 1 billion SEK from 2008 to 2016 (corporation tax and income tax) due to a 1.3 billion SEK drop in the sector's corporation tax, whilst contributions from employees' income tax have increased. The fact that income tax has risen whilst the number of employees in the sector has fallen is related to the shift in the sector to more highly trained employees that took place in the same period.

Medicon Valley is the leading life science centre in Scandinavia

58% of those employed in the Danish and Swedish life science sectors in 2016 were employed in Medicon Valley. That is more

than twice as many as in the second-largest Scandinavian life science cluster, the Stockholm-Uppsala region, where

21% of the Danish-Swedish life science sector was employed in 2016.



PHOTO: NEWS ØRESUND

Patents — biotech still dominates Danish applications

Developments in the number of patent applications can offer indications about future developments for the life science companies of Medicon Valley as well as nationally in Denmark and Sweden. Danish companies sought 643 life science patents from the European Patent Office (EPO) in 2017. This is a 15% increase compared to 2016, and the highest number of life science patents sought since 2010. Swedish companies also sought more life science patents in 2017 than in 2016. With 355 life science patents sought in 2017, which corresponds to a 6% increase, the positive development since 2014 in the number of life science patent applications to EPO by Swedish companies continued, according to statistics from EPO.

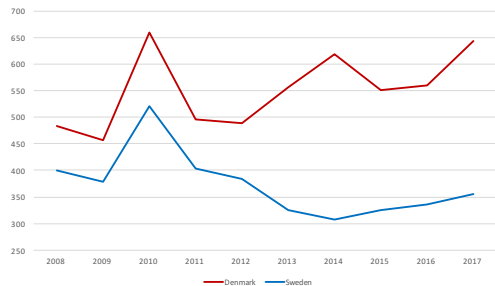
Leading Danish and Swedish life science companies are among the 25 top applicants to EPO. Novo Nordisk is on the Top 25 list in the categories Medical Technology, Biotechnology and Pharmaceuticals, and Novozymes in Biotechnology. Novozymes was the third most frequent applicant in biotechnology at EPO in 2017. The only life science company with activity in Sweden on the EPO's Top 25 list is Astra Zeneca (pharmaceuticals), but its presence owes to

research activity in other countries than Sweden.

Note that the patent application year refers to the publication date, which is 18 months after the filing of the national application.

While biotech topped the list over the technology fields within which Danish applicants filed most patent applications to the EPO again in 2017 (290), medtech is the technological field for which Danish applicants filed the second most patent applications in 2017 (231). In general, life science patent applications (biotech, medtech and pharmaceuticals) top the list in terms of the number of patents sought by Danish companies both in 2017 and for the period 2008–2017, whilst Sweden's areas of strength are ICT (digital communication and telecommunications) and mechanical engineering within transport, according to statistics from the EPO. For Swedish companies, medtech placed third in 2017 with 196 applications and held fourth place for the period 2008–2017 (2 335), whereas pharmaceuticals placed 13 with 90 applications in 2017. The number of Danish life science patent applications to EPO in the period 2008–2017 increased 33%, while the number of Swedish life science patent applications to EPO decreased 11%.

LIFE SCIENCE PATENT APPLICATIONS TO EPO FROM SWEDEN AND DENMARK



Source: EPO

643

Danish life science patent applications to EPO in 2017 – the highest number since 2010.



PHOTO: NEWS ØRESUND

TOP TEN TECHNOLOGICAL FIELDS REPRESENTED IN DANISH AND SWEDISH PATENT APPLICATIONS FOR THE PERIOD 2008–2017 AND 2017 (IN PARENTHESES)

SWEDEN			DENMARK	
Place	Technological field	Number of applications	Technological field	Number of applications
1	Digital communication	8 152 (1 156)	Biotechnology	2 410 (290)
2	Telecommunications	2 673 (177)	Medical technology	1 844 (231)
3	Transport	2 578 (243)	Engines, pumps, turbines	1 289 (169)
4	Medical technology	2 335 (196)	Pharmaceuticals	1 259 (122)
5	Computer technology	1 747 (160)	Civil engineering	1 235 (137)
6	Mechanical elements	1 423 (116)	Audio-visual technology	996 (135)
7	Measurement	1 267 (127)	Other special machines	788 (96)
8	Civil engineering	1 257 (136)	Food chemistry	757 (79)
9	Machine tools	1 057 (96)	Electrical machinery, apparatus, energy	724 (76)
10	Other special machines	956 (91)	Measurement	641 (88)
...				
16	Pharmaceuticals	803 (90)		
20	Biotechnology	599 (69)		

Source: EPO. Reading this table: The first figure denotes the number of patent applications for the entire period of 2008–2017 within the respective technological fields. The figure for the number of patent applications in 2017 is in parentheses. The year indicates the publication date, which is 18 months after the filing of the national application.

Greater Copenhagen

MEDICON VALLEY is the bi-national life science cluster spanning the island of Zealand in Eastern Denmark and the Skåne region of Southern Sweden. Today, the Danish-Swedish region is marketed inter-

nationally with the name 'Greater Copenhagen', and its increasing population has reached four million residents. In Sweden, the same geographical area is often called the 'Øresund Region'.



THE BEACONS OF MEDICON VALLEY: Renewal with stable ownership

PHOTO: NOVO NORDISK

Four large life science companies run by industrial foundations are an important part of Medicon Valley's success. With nine universities and seven science parks, the region has a highly developed system for research and innovation that is an important part of the companies' development of new pharmaceuticals. There is also a growing number of biotech companies in the region, as well as large medtech companies and a globally leading cluster of hearing aid manufacturers.

- The Novo Nordisk Foundation, The Lundbeck Foundation, Dr Frederik Paulsen Foundation and the LEO Foundation control the ownership of Medicon Valley's largest companies: Novo Nordisk, H. Lundbeck, Ferring Pharmaceuticals and LEO Pharma. Foundation ownership prevents acquisition and thus secures the companies' continued presence in the region in the future. Foundation ownership also means that company management can act with a long-term perspective. Some of the foundations invest in new biotech companies and make large donations to universities and innovation systems in the region.
- Medicon Valley is also home to a globally leading cluster of hearing aid manufacturers: Oticon, GN Resound and Widex.
- For a number of years now, biotech companies have been in a positive development phase once again. Some of the largest biotech companies are Genmab, Zealand Pharma, Bavarian Nordic, Alligator Bioscience and Camurus.
- There are also many medtech companies in the region, such as Coloplast, Baxter (formerly Gambro), Arjo, Nolato Medical and Atos Medical.
- Medicon Valley's academic spectrum in the life sciences is broad, with nine learning institutions that do research in the field. Globally leading diabetes research and neuroscientific research take place at the University of Copenhagen, as well as at Lund University. The learning institutions also have other strong life science research, for example on metabolic diseases and plant biology. In addition, DTU and Malmö University are both highly advanced in areas such as bioengineering and biological surfaces.

DANISH FOUNDATIONS OFFER STABILITY FOR MEDICON VALLEY'S LARGEST LIFE SCIENCE COMPANIES

Medicon Valley is dominated by four large Danish life science companies, all of which are run by private owner foundations. Two of the four companies are publicly traded. Foundation ownership is part of why the large pharmaceutical companies still have their bases in Medicon Valley whilst focusing on clear niches. The region's four science parks and nine universities are instrumental for the businesses' new product development and new business growth.

THE NOVO NORDISK FOUNDATION GROUP

Novo Nordisk Foundation is an industrial foundation whose objective is to act as majority shareholder in the publicly traded Novo Nordisk and Novozymes, as well as to support scientific, humanitarian and social causes.

Novo Holding is the Foundation's wholly owned subsidiary. It manages the Foundation's endowment and its controlling interests in the publicly traded companies Novo Nordisk and Novozymes. Via the platforms Seeds,

Ventures and Principal Investments, investments are made in external biotech companies at various stages of development. Novo Holding also has 12 large, more long-term investments, including investments in five Danish companies: Chr. Hansen, Sonion, Symphogen, Veloxis Pharmaceuticals and Xellia Pharmaceuticals.

Novo Nordisk is the original company behind the group, and today it is Denmark's largest pharmaceutical company and a globally leading producer of

THE BEACONS OF MEDICON VALLEY

insulin. The company is publicly traded and has its headquarters and a large facility on the outskirts of Copenhagen, in Bagsværd, and several large research and production facilities elsewhere in Zealand. The company also makes drugs for obesity, haemophilia and growth disorders.

Turnover 2017: 111.7 billion DKK

Number of employees 2017: 42 682, of whom 16 429 in Denmark and 83 in Sweden.

Facilities in Medicon Valley: Headquarters in Bagsværd and offices in Ørestad and Malmö. Research facilities in Måløv and Hillerød. Production facilities in Værløse, Søborg, Måløv, Gentofte, Køge, Kalundborg and Hillerød.

NOVOZYMES was founded in 2000 as a demerger from Novo Nordisk. Novozymes is a publicly traded biotechnology company and a globally leading manufacturer of industrial enzymes as well as a major producer of microorganisms. The company's headquarters is in Bagsværd outside Copenhagen.

Turnover 2017: 14.5 billion DKK.

Number of employees 2017: 6 245, of whom 2 631 in Denmark.

Facilities in Medicon Valley: Headquarters and R&D in Bagsværd and production facilities in Kalundborg and Copenhagen.

THE LUNDBECK FOUNDATION

Is an industrial foundation whose objective is to maintain and expand the activities of H. Lundbeck and to provide funding for scientific research. The Foundation is the largest shareholder in the publicly traded companies H. Lundbeck and ALK-Abelló, as well as in Falck A/S. The Foundation also invests in life science companies.

H. Lundbeck is a global pharmaceutical company specialising in drugs for psychiatric and neurological disorders. The company is publicly traded and has its headquarters in Valby, Copenhagen. Several new compounds have been launched in recent years against for example depression and schizophrenia, while other, earlier patents have expired.

Turnover 2017: 17.2 billion DKK

Number of employees 2017: 5 181, of whom 1 669 in Denmark and 79 in Sweden.

Facilities in Medicon Valley: Headquarters and production in Valby/Copenhagen and production in Odsherred. Office in Malmö.

FERRING PHARMACEUTICALS

Is a wholly privately owned pharmaceutical company with its roots around the Øresund. It was founded in Malmö in 1950 and moved to Limhamn in 1956, with subsidiaries in Denmark and Germany that are now a group.

In 2002, operations in Copenhagen and Limhamn were consolidated and moved to the iconic black high-rise in Ørestad, and in 2004 the company headquarters moved to Switzerland. Ferring is run by Frederik Paulsen through the Dr Frederik Paulsen Foundation.

Ferring is still represented in its former hometown Malmö, where it has an office. There are also a number of pharmaceutical companies in Malmö with a historic link to Ferring: PolyPeptide Group, Qpharma, Nordic Drugs and Euro Diagnostica.

Turnover 2017: 1.92 billion EUR

Number of employees 2017: 6 500, of whom 556 in Denmark and 17 in Sweden

Facilities in Medicon Valley: Ferring Pharmaceuticals A/S, also called Ferring International Pharma Science Centre, and Ferring Lægemedler A/S in Ørestad, and a sales office in Malmö and API-manufacturer Syntese in Hvidovre Municipality. Headquarters in Switzerland.

LEO FOUNDATION

Was established in 1984 to secure LEO Pharma's future as an independent, research-based Danish pharmaceutical company. The foundation also supports international research with focus on dermatology.

LEO Pharma is an entirely privately/foundation-owned pharmaceutical company with focus on the development and production of medicines for dermatology and thrombosis.

Turnover 2017: 10.5 billion DKK

Number of employees 2017: 5 700 of whom 2 052 in Denmark and 25 in Sweden.

Facilities in Medicon Valley: Headquarters, R&D and production in Ballerup outside Copenhagen.

GLOBALLY LEADING HEARING AID MANUFACTURERS

Around Copenhagen there is a globally leading cluster of hearing aid manufacturers: Oticon, GN Resound and Widex, that decided this year to merge with German Sivantos, formerly known as Siemens Audiology.

MEDTECH MORE COMMON IN SKÅNE

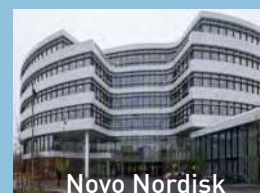
Coloplast is the largest medtech company in Zealand. There are several large companies in Skåne, such as Baxter (formerly Gambro), Arjo, Nolato Medical and Atos Medical.

BIOTECH IS GROWING AGAIN

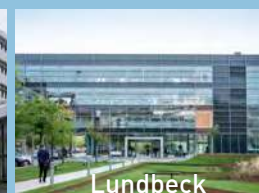
There are thriving biotech companies on both the Swedish and Danish sides of Medicon Valley, such as Bavarian Nordic, Genmab, Zealand Pharma, Symphogen, Alligator Bioscience and Camurus.

Figures for companies' turnover and number of employees have been supplied by the companies themselves.

THE BEACONS OF MEDICON VALLEY



Novo Nordisk



Lundbeck



Ferring



LEO Pharma

4 **PHARMACEUTICAL COMPANIES** with headquarters or former headquarters in the Zealand region dominate Medicon Valley's largest groups in pharmaceuticals and biotechnology. The four large groups Novo Nordisk, Lundbeck, Ferring and LEO Pharma and the foundations that own them have also acted as a venture capital investor and a nursery for many of the researchers in Greater Copenhagen. A number of biotechnology companies have emerged since the late 1990s, such as Genmab, Zealand Pharma, Bavarian Nordic and Symphogen in Denmark and Alligator Bioscience and Camurus in Skåne.

SUCCESS STORY. Pharmaceutical and biotech companies in Greater Copenhagen are a success story characterised by a few large companies in pharmaceuticals complemented by successful biotechnology companies. But Medicon Valley is more than just pharmaceuticals and biotech. The region also has successful medtech companies, growing science parks and the two large materials research facilities MAX IV and European Spallation Source, the latter of which is currently under construction in Lund, and ESS data management centre DMSC in Copenhagen.



5 **SCIENCE PARKS** in Medicon Valley completely or significantly focus on the life sciences: COBIS, DTU Science Park, Ideon, Medeon and Medicon Village. Also included are the start-up ecosystem Symbion and the food- and health-oriented science park Krinova, which focus partially on the life sciences. There are around 1 500 companies with a total of approximately 17 000 employees in these science parks.



Lund university

9 **UNIVERSITIES.** Greater Copenhagen's academic spectrum in the life sciences is broad, with nine learning institutions conducting research in the field. Globally leading diabetes research and neuroscientific research take place at the University of Copenhagen, as well as at Lund University. The learning institutions also have other strong life science research, for example on metabolic diseases and plant biology. In addition, DTU and Malmö University are both highly advanced in areas such as bioengineering and biological surfaces.

NEW INVESTMENTS TRANSFORMING FERRING

Ferring Pharmaceuticals' owner and chairperson Frederik Paulsen is aiming to completely transform the company, whose roots are around the Øresund and headquarters in Switzerland, within 10 years. In just a short time, Ferring has invested in new research platforms with which it expects to establish wide-ranging collaborations and research contracts. Ferring's new research facility Soundport is currently taking shape on the shores of the Øresund Strait, close to Copenhagen Airport.

It's been almost 70 years since the pharmaceuticals company Ferring was founded on the shores of the Øresund, and today it is entering a period of great transformation.

– We've strengthened our microbiota platform with the acquisition of Reebotix, which is one of the leading companies in the field in the USA. Those operations are now being integrated with our other microbiota activities, in particular with our cooperation with the Karolinska Institute to accelerate new product development. Ferring Holding has also acquired a platform for the treatment of bladder cancer, says Frederik Paulsen, chairman of Ferring Pharmaceuticals, and owner via the Dr Frederik Paulsen Foundation.

The new investments are a complement to Ferring's existing therapeutic areas: reproductive medicine and women's health, gastroenterology and urology. Frederik Paulsen explains that the new research platforms have such great potential that he expects that Ferring will need to find new collaborations and enter large-scale research agreements.

– Because of the new platforms, Ferring can be completely transformed within 10 years. We actually don't have a choice. Technological changes happen at such an astounding pace. In the 1990s and 2000s there was a dip in pharmaceutical research, but now we've entered a new era with groundbreaking discoveries, not least in cancer treatment.

Since it started in Malmö in 1950, Ferring has grown into a global group of companies with 6 500 employees, subsidiaries in almost 60 countries and a turnover of €1.92 billion in 2017. Today, its headquarters are in Saint-Prex in Switzerland, and the activities in the Øresund Region have moved from Copenhagen and Malmö to Ørestad and a factory in Hvidovre. Due its continued expansion, Ferring has grown out of its premises in Ørestad and is now investing €150 million in the construction of the new research facility Soundport, which is being built on a narrow strip of land near Copenhagen

Airport, facing the sea and with a view of Malmö on the other side. Construction is expected to be complete in 2020.

– It's enormously satisfying for me that we can establish ourselves there. The location near the airport is fantastic, and Sweden is right across the Øresund Strait. In a way it's a confirmation of our rootedness in the Øresund Region. As long as I have something to say about it, Ferring will be here. It's also in a sense a monument to my stepmother. My father was a great intellectual, the researcher who could talk for hours about peptides. My stepmother studied chemistry at the University of

Copenhagen and she was the one who developed a lot of our production methods. I see it as my duty to acknowledge her, as she was just as responsible for our success as my father, says Frederik Paulsen.

The large global expansion of Ferring's operations took off when Frederik Paulsen became the company CEO in 1983, taking over the Swedish company from his father and namesake. In 1988 Frederik Paulsen became chief executive officer. Long-term vision and ethics are more important than quick profit however, he emphasises, and he turns to Ferring's development in the USA.

– It took 17 years of investments before we started making money in the USA. Our growth has been steady everywhere else, but the turbo boost comes from the USA. We don't only have sales there; we also have production and research in San Diego and pharmaceuticals research development at our production facility in New Jersey.

Ferring continues to invest in new research facilities. In early 2018, the decision was made to invest 30 million CHF in Ferring Biotech Centre in Saint-Prex. Another factory is being built in India, and research work there is also being expanded. A research facility is being set up in China, and two new factories are being built in Russia. A develop-



The groundbreaking ceremony for Ferring's new research facility Soundport was on 5 September 2016. The facility will be ready for use in 2020.

ment lab is being started in Brazil.

– My personal opinion is that if you go into a market like India, China or Japan, you can't just sell your products. We need to show that we're engaged in the country with local production, research or product development so that we aren't seen as some big, anonymous international corporation, says Frederik Paulsen.

Long-term expansion and development have been more important than short-term profitability.

– Profit has never been our primary goal. We have a profit of about ten per cent after taxes. We could easily get up to 20% profit, but that would slow down our development pace and our investments in facilities and products.

Frederik Paulsen emphasises that privately-owned companies like Ferring have their advantages and disadvantages. Among the advantages is the possibility for a long-term perspective building up employees' competence. A disadvantage he points out is that a privately-owned company doesn't feel the same pressure to raise profits as its publicly traded competitors do.

The Paulsen-sphere's involvement in Malmö is one example of long-term thinking. The Swedish marketing agency is still here, and Ferring's former factory in Limhamn is on lease to the Chinese pharmaceuticals company Rechon Life Science. There is also a series of companies in Malmö that are part of a pharmaceuticals group owned by a separate foundation associated with Frederik Paulsen. In Malmö, the group owns companies such as Eurodiagnostica and Nordisk Pharma, as well as the manufacturing

companies Qpharma and Polypeptide.

– The Polypeptide Group has an annual turnover of between €170 – €180 million. That's more than what Ferring was turning over when it was in Malmö, says Frederik Paulsen.

The investments on both sides of the Øresund are an indication of his belief that the Øresund Region still has potential "as a hub for the development of pharmaceuticals and diagnostics in Europe".

– The people in charge should be doing everything they can to development the region's competitive strength. The high level of competence is an asset. But it's fascinating to see the tax competition going on around the world to bring in high tech. Authorities in Denmark and Sweden need to be aware of that.

FERRING PHARMACEUTICALS

Founded in 1950 in Malmö by Dr Frederik Paulsen and Eva Frandsen under the name Nordiska Hormonlaboratoriet, later changed to Ferring.

1961: Ferring begins industrial production of peptide hormones.

1983: Frederik Paulsen's son Frederik Paulsen Jr is appointed CEO of Swedish Ferring, and he begins coordinating Ferring's activities in Sweden, Denmark and Germany to a corporate group.

1988: Frederik Paulsen Jr becomes group chief executive.

2002: Ferring's operations in Copenhagen and Limhamn move to Ørestad.

2004: Ferring's headquarters move to Switzerland.

A 110-YEAR-OLD COMPANY WITH A START-UP FEELING

Innovative capacity is just as important as short-term profit. LEO Pharma's owner foundation has given the green light for an increase in R&D investments corresponding to 25% of its turnover, even if that means there will be digits in red on the bottom line for a few years. Until 2025, the strategy is about investments in biopharmaceuticals and potential gene therapy, artificial intelligence, patient apps and more collaboration.

LEO Pharma has shed its skin several times. After its start 110 years ago, the company developed into a pioneer of the pharmaceutical industry in Denmark and Sweden before growing into a conglomerate with animal feed and plastic packaging in its product range. Since 2008 the focus has been back on pharmaceuticals with an emphasis on dermatology. At the same time, LEO Pharma has grown from a northern European company to a global player with research facilities in the USA and China.

The number of employees has risen from around 3000 in 2008 to 5 700 people in 61 countries in 2017. The base is still the large facility with headquarters in Ballerup near Copenhagen. LEO Pharma's Swedish subsidiary is in Hyllie, on the outskirts of Malmö. More than 2 000 of the company's employees work in Medicon Valley, and the majority of them are on the Danish side of the Øresund. 75 people commute from Skåne to the facility in Ballerup daily.

The next big step in the renewal of LEO Pharma was taken in a partnership with AstraZeneca that meant that the company could launch the biopharmaceutical Kyntheum for moderate-to-severe psoriasis. Phase III studies are currently being done for a biopharmaceutical to treat eczema called tralokinumab.

Heading the renewal efforts is LEO Pharma's CEO Gitte Aabo, who began working at the company 26 years ago. In 1999 she became part of the company management team, and ten years ago she was appointed CEO. When she describes the company's new strategy "Helping Sarah - LEO towards 2025", she speaks more about patients as individuals than about LEO Pharma's profit goals. One figure that she highlights is the number of patients the company helps; that number should increase from 80 million in 2017 to 125 million in 2025.

– For me, the personal motivation for working in the pharmaceuticals industry and at LEO is that we

make a difference for people. With Helping Sarah, we want to show that our patients are individuals. Many of the disorders for which we offer treatments are chronic; people don't consider themselves patients, but rather as people for whom the disorder is a part of life. Because we are owned 100% by the LEO Foundation, the company's primary goal isn't to make money for shareholders, but to make money in order to develop and deliver better solutions for our patients, says Gitte Aabo.

"With Helping Sarah, we want to show that our patients are individuals."

Innovative capacity is considered equally important as short-term profitability – that is apparent from the board's approval of LEO Pharma increasing R&D investments up to 25% of turnover, and allowing profitability to drop temporarily so that an individual year might even close with red digits on the annual statement. To compare, LEO Pharma's turnover exceeded 10 billion DKK for the first time in 2017, and the company's net profit almost doubled to 1.4 billion DKK – almost at the level of that good year 2014.

Gitte Aabo explains that the company's strategy separates operations into two parts. The established pharmaceuticals portfolio still forms the financial foundation that will fund the new investments in biopharmaceuticals and potentially gene therapy.

– It's important that we run effective operations there so we have more resources to invest in R&D, she points out.

Acquisitions and sales are also being made to renew the product portfolio. In March a product portfolio with ten pharmaceutical products was sold to Swedish Karo Pharma. This summer, it was determined that LEO Pharma would acquire Bayer's global portfolio of prescriptions dermatology products.

LEO Pharma's future expansion in dermatology is in new technological areas with biopharmaceuticals, po-



Gitte Aabo, CEO LEO Pharma.

tentially gene therapies, and digital analytic products.

– We expect that three-fourths of our pipeline with new products will come from partnerships in the future. Our ambition is to become the world's leading company for dermatology. That doesn't necessarily mean that we'll be the largest, but we want to be the ones that know the most. We have a different focus on skin disorders than large companies such as for example Novartis, says Gitte Aabo.

In recent years, LEO Pharma has had a number of initiatives to renew its research and development. An investment in open innovation meant inviting external researchers to share the company's expertise. LEO Innovation LAB is another major investment in developing everything from apps and digital solutions to diets, health care and mental training programmes to help skin patients improve their quality of life.

– We can create tools using artificial intelligence that help doctors make better diagnoses, and with the help of mobile phones and image analysis, we can help patients keep track of their treatments and see improvements before they are visible to the human eye, says Gitte Aabo.

She explains that the new technology will step up patients' influence over their treatments, which will impact pharmaceutical companies' business models in the future.

The strategy highlights five trends concerning increased patient empowerment, rising pricing pressure and demographic changes with an ageing population. But most of all the emphasis is on the huge influence that new technologies and digital disruption are expected to have on future activities.

LEO PHARMA – DANISH AND SWEDISH PIONEERS

Originally called Løvens Kemiske Fabrik, the company was started in 1908 and was a pioneer of Danish and Swedish life science.

In 1914 a Swedish subsidiary was founded in Helsingborg. After changing hands a number of times, it is now known as McNeil and is part of the Johnson & Johnson company.

In 1912 they launched the painkiller Albyl, and in 1917 the drug Digisolvin because Denmark's first pharmaceutical export. In 1923 the company began insulin production, which was transferred only two years later to the independent Nordisk Insulinlaboratorium; over the years, this developed into the pharmaceutical giant Novo Nordisk. In 1945 it launched the first penicillin preparation outside of the USA and the UK. In 1984 the LEO Foundation was created as the sole owner of LEO Pharma, which had developed into a conglomerate with everything from pharmaceuticals to animal feed and plastic packaging in its product range.

In 2008, after selling all of its other activities, LEO Pharma became a strictly pharmaceuticals company once again.

In 2017 the next step in the company's renewal began to take shape with the launch of Kyntheum, a biopharmaceutical for the treatment of moderate to severe psoriasis. The launch was made possible by a partnership with AstraZeneca.

CLUSTER RANKING: A unique comparison of ten European life science clusters

PHOTO: REGION SKÅNE ROGER LUNDHOL

Between 2006-2016, Medicon Valley experienced the greatest percentual increase in the number of scientific publications compared to nine other outstanding European life science clusters. This was shown by an analysis done by the research centre CWTS on behalf of Medicon Valley Alliance. In the comprehensive comparison, the Danish-Swedish region comes in sixth for both publications and citation frequency.

- Researchers in Medicon Valley produced 32 027 scientific publications in the life sciences in the period studied, 2006-2016. From 2006-2017, 13% of them were among the ten per cent most frequently cited in their respective fields.
- The European life science clusters in the comparison that brought out the greatest number of scientific publications in the period investigated were London-Cambridge-Oxford (116 263), the Netherlands (90 779) and BioValley, a German-French-Swiss cluster that includes Basel, Alsace, Freiburg, Karlsruhe, Mulhouse and Strasbourg (49 925). The clusters with the largest proportion of scientific publications among the ten per cent most frequently cited globally for their respective fields were London-Cambridge-Oxford (17%), Zurich (16%) and Scotland (15%). The clusters in the comparison that resemble Medicon Valley most closely are Stockholm-Uppsala, Flanders, and to a degree, Munich.
- International collaboration was a part of 54% of Medicon Valley's scientific publications, and it leads to significantly more citations than publications resulting from national collaborations of the work of individual research groups. The research networks in the transborder Medicon Valley region are predominantly national, though.

MEDICON VALLEY MIDPOINT FOR EUROPE- AN LIFE SCIENCE CLUSTERS FOR SCIENTIFIC PUBLICATIONS AND CITATIONS

32 027 scientific publications in the life sciences were produced by researchers at universities, other research institutions and businesses in Medicon Valley between 2006 and 2016. Of these, 13% are among the ten per cent most frequently cited in the world for their respective fields. Seen globally, the result is above average, but compared with a selection of nine other strong life science clusters in Europe, it is just enough for a position just below the middle.

– While it's nothing to boast about, it could be improved with more cooperation, says Vice Chancellor of Malmö University Kerstin Tham when asked about Medicon Valley's results in the comparative analysis conducted by the Dutch research institute CWTS from Leiden University on behalf of Medicon Valley Alliance.

The other university representatives interviewed for this analysis were not particularly impressed by Medicon Valley's placement either, but nor were they disappointed. The results are more or less what they expected in relation to the other clusters. In

the report Benchmark Life Science Regions Research for Medicon Valley Alliance 2006-2016/17, CWTS writes that "the benchmark field in this representation is a rather strong one".

Unsurprisingly, the greatest number of publications, 116 263, were written by researchers in the life science cluster around London-Cambridge-Oxford during the period analysed (2006-2016). That is followed by the Netherlands, whilst the remaining eight clusters – BioValley, Flanders, Île de France, Medicon Valley, Munich, Scotland, Stockholm-Uppsala and Zurich – are somewhat lower and rather densely

A unique comparison of ten European clusters

On behalf of Medicon Valley Alliance, the Dutch research institute CWTS at Leiden University performed a bibliometric comparison of ten European life science clusters based on their total influence in the research world.

54%

The percentage of the scientific publications in Medicon Valley that resulted from international collaborations. 26% were published in cooperation with other researchers in the same country, and 19% were by researchers or groups without collaborative partners.

Three large, contemporary research endeavours in the life sciences in Medicon Valley

- DTU is gathering 300 researchers in a new Institute for Health Technology, which will start up on 1 January 2019. The aim is to create synergistic effects and to put a face on health tech at the university.
- The BioInnovation Institute in Copenhagen, funded with 392 million DKK from the Novo Nordisk Foundation during its three-year start-up phase, aims to make it easier for researchers to commercialise their research.
- A new plant breeding centre for food crops has been started at SLU Alnarp, after the Swedish government allocated 90 million SEK for its establishment. The centre aims to produce new crops adapted for a Swedish climate in change.

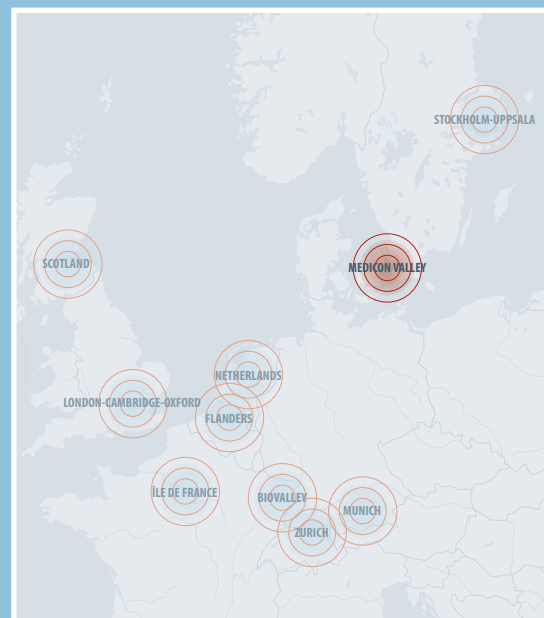


ILLUSTRATION: LØNNEGÅRD & CO

Greatest impact of scientific publications 2006-2016/17 (number of citations in relation to the average [=1] for each subject area)

1. London-Cambridge-Oxford (1.46)
2. Scotland (1.35)
3. Zurich (1.34)
4. The Netherlands (1.33)
5. Munich (1.21)
6. Medicon Valley (1.20)
6. Stockholm-Uppsala (1.20)
8. Flanders (1.15)
9. BioValley* (1.14)
10. Île de France/Paris (1.09)

Citations calculated for the years 2006-2017.

*A German-French-Swiss cluster that includes Basel, Alsace, Freiburg, Karlsruhe, Mulhouse and Strasbourg

INTERNATIONAL COLLABORATION GRABS ATTENTION. CWTS' comparative analysis shows that scientific publications co-published with international researchers are cited significantly more frequently than those published by researchers who worked independently or collaborated nationally. The difference between the two latter types of publications is marginal.

23%

The increase in the number of scientific publications in Medicon Valley between 2006-2009 and 2013-2016.

Universities want to expand trans-Øresund research cooperation – this is how

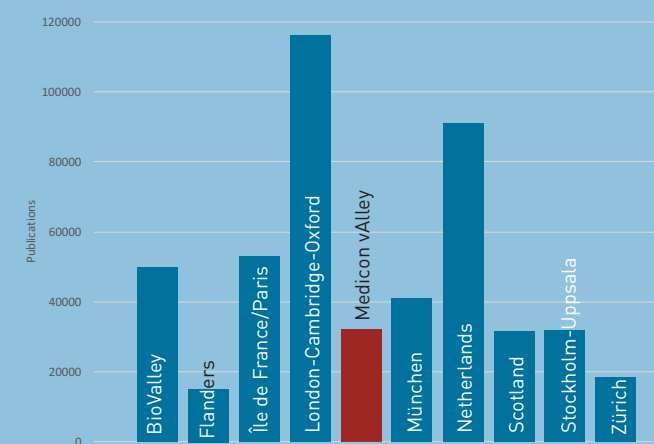
Targeted research funds for trans-border collaboration and joint educational training for students to meet and get to know one another are two ways that representatives for the universities in Medicon Valley believe research collaboration between Sweden and Denmark could be expanded.



PHOTO: NEWS ØRESUND

NATIONAL NETWORKS ARE STRONGEST. A network analysis from the research institute CWTS shows that the region's national networks are significantly stronger than trans-Øresund networks, and in Medicon Valley national cooperation is far more common than cooperation between Denmark and Sweden.

Number of scientific publications per cluster 2006-2016



32 027 scientific publications were produced by researchers in Medicon Valley between 2006-2016, placing the region seventh among the clusters compared. The greatest number of scientific publications in the field were published by researchers in London-Cambridge-Oxford: 116 263, followed by researchers in the Netherlands, who produced 90 779 scientific publications in the same period.

More Danish hospitals with clinical research

There are more hospitals involved in research in Denmark than in Sweden, a network analysis by CWTS shows. On the Swedish side of the Øresund Strait, clinical research is concentrated almost exclusively at Skåne University Hospital.



PHOTO: NEWS ØRESUND

academic researchers work in the life sciences in Medicon Valley.

arranged in terms of their publication volume.

If one looks instead at the proportion of each cluster's publications that is among the ten per cent most frequently cited for its field (citations have been calculated for 2006-2017), London-Cambridge-Oxford remains decisively highest at over 17%, and is followed by Zurich, Scotland and the Netherlands at around 15%.

The remaining six life science clusters, including Medicon Valley, are around 12-13%.

– London-Cambridge-Oxford is one of the world's best clusters. Seen in its context and with the investments made in Medicon Valley, we are satisfied with the level we're at now. Because if we look at how our research is being cited and the impact it has, we see it as having successfully filled a quality criterion, says Vice Dean of Research at the Faculty of Health and Medical Sciences at the University of Copenhagen Mogens Holst Nissen.

Increase in publication volume

Representatives for the universities were all the more pleased that the region's researchers had produced more scientific publications in the 11-year period under scrutiny. From the period 2006-2009 up to and including the period 2013-2016, the number of publications in the life sciences produced by researchers from Medicon Valley increased 23%, from 10 465 publications to 12 902, which is the greatest percentual increase in all of the clusters in the comparison, although the actual number of articles published by Dutch researchers increased more in absolute numbers. The number of publications for most of the other clusters remained more or less stable throughout the entire period.

– We see the increase in activity as a rising number of publications as something positive. The development, particularly in research, is reflected in the long-term, so the investments made now will have a long-term effect. But that is true of both positives and negatives – if there are sharp cutbacks, it might not be noticeable here and now, but it will be in the future, says Mogens Holst Nissen.

While the number of life science publications in Medicon Valley has increased, research impact has remained at the same level; in this case, it is measured by the number of articles among the ten per cent most frequently cited in each field. In just one of the periods measured, 2010-2013, this number temporarily rose to 14%. Otherwise, it has remained stable at 13%.

If one looks at the other clusters a rise by one percentage point seems more a rule than an exception.

That Medicon Valley has not been able to increase its impact is problematic in this case, says Dean

of Research Katrine Krogh Andersen from DTU.

– Looking at DTU's research, we work hard to increase DTU's citation impact and the impact of our research as a whole. It is something we measure and look at broadly for the entire university. It's exasperating if there is a greater number of publications without an increase in impact, she says.

The interpretations differ between various university representatives however. Pro Vice-Chancellor of Lund University Bo Åhrén, on the other hand, believes that it is positive that Medicon Valley has remained at 13% although the number of publications has increased.

– Research impact is at a high level, and it remains high although the number of scientific publications has increased, which is good. It's not that multiple publications are being produced for the same research; in that case the impact would have dropped, he says.

Currency differences and business structure impact Medicon Valley's position in Europe

In the various comparisons in terms of publications and visibility/citation frequency that CWTS has conducted for the ten European life science clusters selected, there is a noticeable pattern; the other clusters that are usually closest to Medicon Valley are Stockholm-Uppsala and Flanders, and to an extent also Munich. These clusters are also somewhat similar to Medicon Valley in terms of size, whilst e.g. London-Cambridge-Oxford and the Netherlands are significantly larger and have a completely different set of conditions.

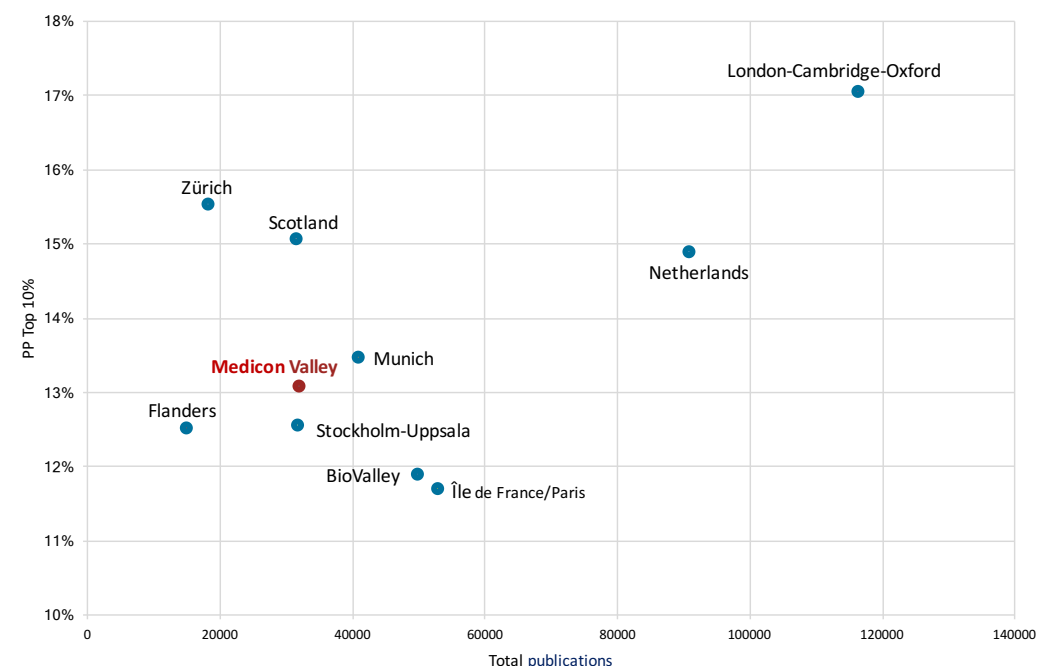
This analysis has been conducted with the aim to obtain a picture of Medicon Valley's position in relation to some of the important surrounding clusters with which the region's researchers both compete and collaborate, but without placing it in direct relation to each cluster's unique conditions.

There are many factors that affect the position however; this is something that e.g. Trine Winterø, Vice Dean for Innovation & External Relations at the University of Copenhagen's Faculty of Health and Medical Sciences, also stresses. She points out that a bibliometric comparison only shows one aspect of reality, and the number of publications and citations needs to be interpreted according to the regional conditions – everything from differences in currency to transportation systems.

– All of the parameters, from infrastructure, airlines and which large companies have been built up in the past 150 years – bibliometrics cannot be removed from that context. Denmark and Sweden don't have the Euro, we work transborder here, and that makes it even more difficult than if you live in

OVERALL VISIBILITY OF THE REGIONS (2006-2016/17)

- Researchers in Medicon Valley published 32 027 scientific articles in the field life science between 2006-2016, according to CWTS' review of Web of Science.
- Around 13% of the publications from Medicon Valley were in the 10% most frequently cited for their fields in the entire period of 2006-2017.
- In relation to the nine other life science clusters included in the study, Medicon Valley places in the middle. As far as the number of publications is concerned, Medicon Valley holds a sixth place, and when it comes to the frequency with which these articles are cited in their respective fields, it also comes in sixth. According to CWTS, the group of clusters is very strong.



Source: CWTS B.V.

The diagram shows the total number of publications from 2006-2016 and the number of these that are among the 10% most frequently cited in their fields (PP Top 10%) from 2006-2017.

one country with a single currency and the same transportation system. The number of international headquarters in London-Cambridge-Oxford is far greater than in Medicon Valley. There are no headquarters here besides large pharmaceutical companies – we have national offices and small companies, but the large ones are what's needed for that real, comprehensive development, she says.

According to Erik Bisgaard Madsen, Vice Dean of Public and Private Sector Services at the Faculty of Science at the University of Copenhagen, a true comparison is difficult without taking the factors that differentiate the clusters into account.

– We're relatively relaxed when it comes to qu-

antifications like these. A partial explanation for the result could be that Medicon Valley comprises a mix of large and small universities, whilst some of the other regions have several large universities. That makes a difference, and poses the first difficulty to interpreting results, he says.

The societal importance of research is invisible

It is also important to be aware that bibliometric surveys have advantages – in that they offer an objective comparison with other researchers, research institutions and, as in this case, clusters – as well as limitations.

One problem concerns definitions; life science itself is a vague term with no clear-cut, undisputed

meaning. In the Method section in the Appendix of this report is a more detailed presentation of the topic selection that CWTS made with the help of Medicon Valley Alliance. While this selection was made with the utmost care, and CWTS has an advanced system for categorising journals and publications, it is impossible to prevent some research from falling out of the framework. Katrine Krogh Andersen from DTU points out for example that

some of the university's research, which is published predominantly in technical journals, is also applicable in the life sciences, but that a bibliometric study won't necessarily reflect that.

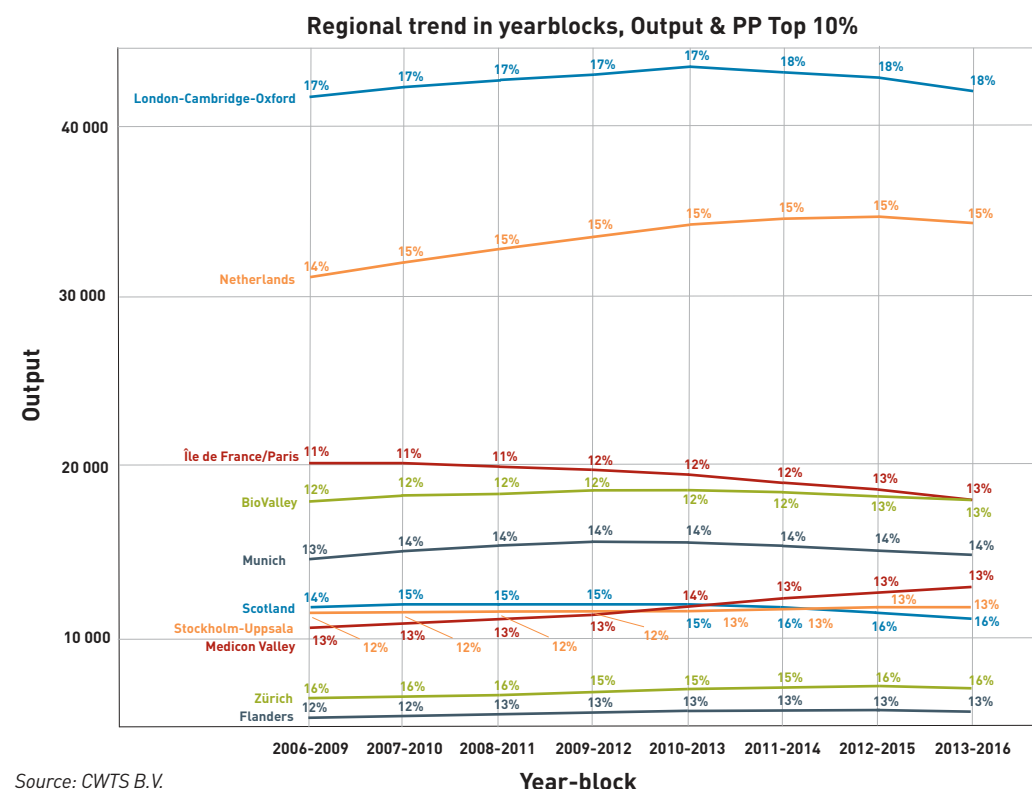
Another issue in terms of comparison is that the research's benefit to society, and its relationship to society, are not measured by bibliometrics.

– I'd like to see its translational impact, together with the industry. What is the importance of the

DEVELOPMENT OVER TIME, 2006 TO 2016/17

- Since 2006, the number of publications in life science by researchers in Medicon Valley has increased steadily, going from just over 10 465 in the first interval studied (2006-2009) to around 12 902 in the most recent interval studied (2013-2016). In absolute numbers, this increase is greater than in any of the other clusters in the comparison, with the exception of the Netherlands. Percentually, it is the greatest increase of all. Most of the other clusters have remained at approximately the same level when it comes to publications in life science for all of the time intervals in the period.

- From 2006-2017, the number of articles among the 10% most frequently cited in their fields remained at the same level – 13% – for Medicon Valley's life science researchers, with the exception of the period from 2010-2013, when the number temporarily increased to 14%. The majority of the other clusters in the comparison have increased their respective numbers of publications among the most frequently cited 10% by one percentage point, or in some cases two.



The diagram shows the number of publications [output] for each four-year interval from 2006-2016, and how many of these were among the 10% in their fields (PP Top 10%) from 2006-2017.

research for the university hospitals, how many products does it lead to, what impact does the encompassing society have on the research being developed and implemented and attracting new jobs and global companies to the area? says Trine Winterø from the University of Copenhagen.

Increased collaboration in the spotlight

Based on the results that CWTS presented in its comparative study, university representatives identify two of the things that are most important to work on for the future: increased international collaboration, and a clearer evaluation of and focus on the region's areas of strength.

Others also call attention to trans-Øresund

collaboration, which itself is international.

According to Mogens Holst Nissen, a cost-benefit analysis of research in the region would also be relevant to determine its value per crown in various environments.

– That is, going in and asking whether there should be broad research coverage. In terms of education, broad coverage might be important, but what about in terms of research? And perhaps identifying the clinical areas where we're particularly strong, as well as the basic research areas, he says.

Kerstin Tham at Malmö University reasons similarly when she says that Medicon Valley could formulate a joint research strategy for e.g. diabetes that would create an international profile for the region.

TEN LIFE SCIENCE CLUSTERS IN COMPARISON

- On behalf of Medicon Valley Alliance, the research institute CWTS at Leiden University has done a comparison of the bibliometric performance of ten life science clusters in Europe, one of which is Medicon Valley:

- London-Cambridge-Oxford
- Netherlands
- Île de France/Paris
- Flanders
- Stockholm-Uppsala
- Scotland
- Medicon Valley
- Zurich
- BioValley (a German-French-Swiss cluster that includes Basel, Alsace, Freiburg, Karlsruhe, Mulhouse and Strasbourg)
- Munich

- In this report, clusters are defined as areas in which universities and other research institutions are fairly densely located in a specific geographic area, where internal collaboration is customary or habitual, and where there is an established cluster organisation of some kind.

- Based on these criteria, we compiled a list of 15 European life science clusters. To do this, we identified the geographic areas that are home to the first 25 universities on the European list of the greatest number of published articles in the field "Biomedical and Health Sciences" in the Leiden Ranking 2012-2015, as well as studying the selection in a number of earlier reports on life science clusters

to avoid overlooking clusters where e.g. there is no single, large university, or transborder clusters.

- We then distilled these 15 clusters to ten by analysing how many articles were published by universities in the 15 European life science clusters, and the frequency with which they were cited. The comparison was done in Leiden Ranking "Biomedical and Health Sciences" 2012-2015.

- The clusters differ in terms of size and the number of research institutions. Some clusters are larger, more well positioned and conduct more research than others. The objective has been to represent the clusters' significance and research positions in relation to one another, and not to show how each cluster performs according to its own unique conditions – a project that would require a significantly larger scope than the present one.

- The comparison has been done for the years 2006-2016. Citations have also been counted through 2017.

- The source was the research database Web of Science, and the publications selected for these regions were limited to those designated to the higher-level category of "Medical and Life Sciences".

- All of the scientific publications in the relevant categories and journals from each region were counted, regardless of whether the research was conducted at e.g. a university, university hospital, other research institutions, or at a commercial enterprise.

MEDICON VALLEY'S RESEARCHERS COLLABORATE MAINLY IN EUROPE

International collaboration is behind 54% of the scientific publications in Medicon Valley, and it leads to significantly more publication citations than for publications resulting from national collaborations or the work of individual research groups. However, the research networks in the transborder region are still predominantly national, according to a network analysis by CWTS.

Co-publication with researchers from other countries results in more frequent citations, and not only for Medicon Valley. CWTS' review of the ten life science clusters in Europe show that the MNCS value – which shows the degree to which publications have been cited in relation to averages (1) in their respective research areas – remain constant at an average of 1.8-1.9 for publications that are the result of international collaborations.

Publications produced with researchers from the same country or without collaboration are significantly lower, and the MNCS average for most clusters is around 1.1 for both categories.

Interestingly however, the clusters that place higher overall usually don't have a larger share of international collaborations, but rather a higher MNCS value for the other two categories as well. This is especially true for London-Cambridge-Oxford and the Netherlands, but also to a degree for Scotland and Zurich.

For publications co-produced with researchers from other countries to be cited more frequently is nothing strange, says Erik Bisgaard Madsen, Vice Dean for Public and Private Sector Services Collaboration at the Faculty of Science at the University of Copenhagen.

– In international collaborations, the best researchers are brought together, and the publications reach a broader audience. They are cited more frequently, and there is an invisible effect as well, since international collaboration itself contributes to a higher citation index, precisely because the number of researchers is greater, he says.

Younger researchers easier to attract

On the whole however, CWTS and the university representatives interviewed for this analysis see expanded international collaboration as the best way to strengthen research in the region. From 2006-2016, 54% of Medicon Valley researchers' publications in the life sciences were written in collaboration with international actors. That placed the region approximately in the middle of the European clusters compared, which in most cases have

around a 50-60% share of international collaboration. The clusters that stand out are Scotland, where 67% of the scientific publications are international co-publications, and at the other end of the spectrum Île de France, which only has 48%.

In Medicon Valley, 26% of scientific publications in the same period were written and published with a national collaboration partner, and 19% without any collaboration. If one looks at the other European clusters, the division between the share of national collaboration and no collaboration is also predominantly even. Only Île de France stands out with a large proportion of national collaboration.

One way to make research more international that is highlighted by universities on both sides of the Øresund Strait would be to increase internal collaboration in Medicon Valley. Another would be to attract international researchers to the region; this is something toward which the University of Copenhagen and others have worked explicitly.

Erik Bisgaard Madsen from the University of Copenhagen believes that an intelligent tactic for the region would be to invest in excellent, somewhat younger researchers with long career ahead of them.

SHARE OF INTERNATIONAL COLLABORATIONS BENCHMARKS 2006 – 2016/17.

Region	Output Share
Scotland	67%
Flanders	62%
Zurich	61%
Stockholm-Uppsala	61%
London-Cambridge-Oxford	59%
Medicon Valley	54%
Netherlands	54%
BioValley	51%
Munich	51%
Île de France/Paris	48%

Source: CWTS B.V.

– You need to look for the blossoming flowers, because we can't really compete for the big, heavyweight senior researchers who can get a job at e.g. Harvard. We can't offer salaries that are as high as in Asia or elsewhere, but if we have the best research infrastructure and possibilities to work public-private as well, we can use that to bring in quality researchers who see good opportunities to develop their careers, he says.

Pro Vice-Chancellor of Lund University Bo Åhrén also believes that it would be intelligent to emphasise the social and personal advantages of

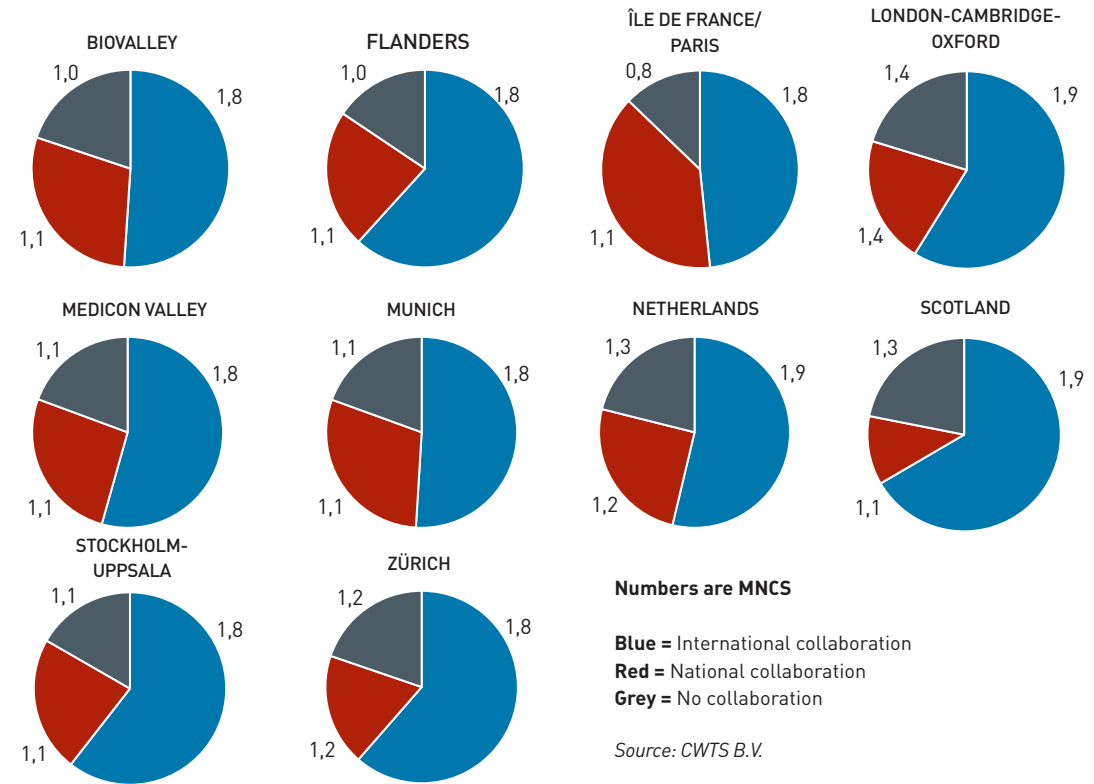
Medicon Valley, for example the proximity to nature and the relatively short distances. At the same time, an organisation and a policy are also necessary to receive the international researchers with schools, research funds and information, he points out.

A number of universities highlight EU funds as a good way to strengthen international collaboration, which itself is frequently a prerequisite for eligibility to receive EU funding.

– We have increased our efforts to bring in EU funding, also because EU funding is a means to collaborate within the EU and with the associated

THE IMPORTANCE OF INTERNATIONAL COLLABORATION FOR RESEARCH VISIBILITY/CITATIONS (2006-2016/17)

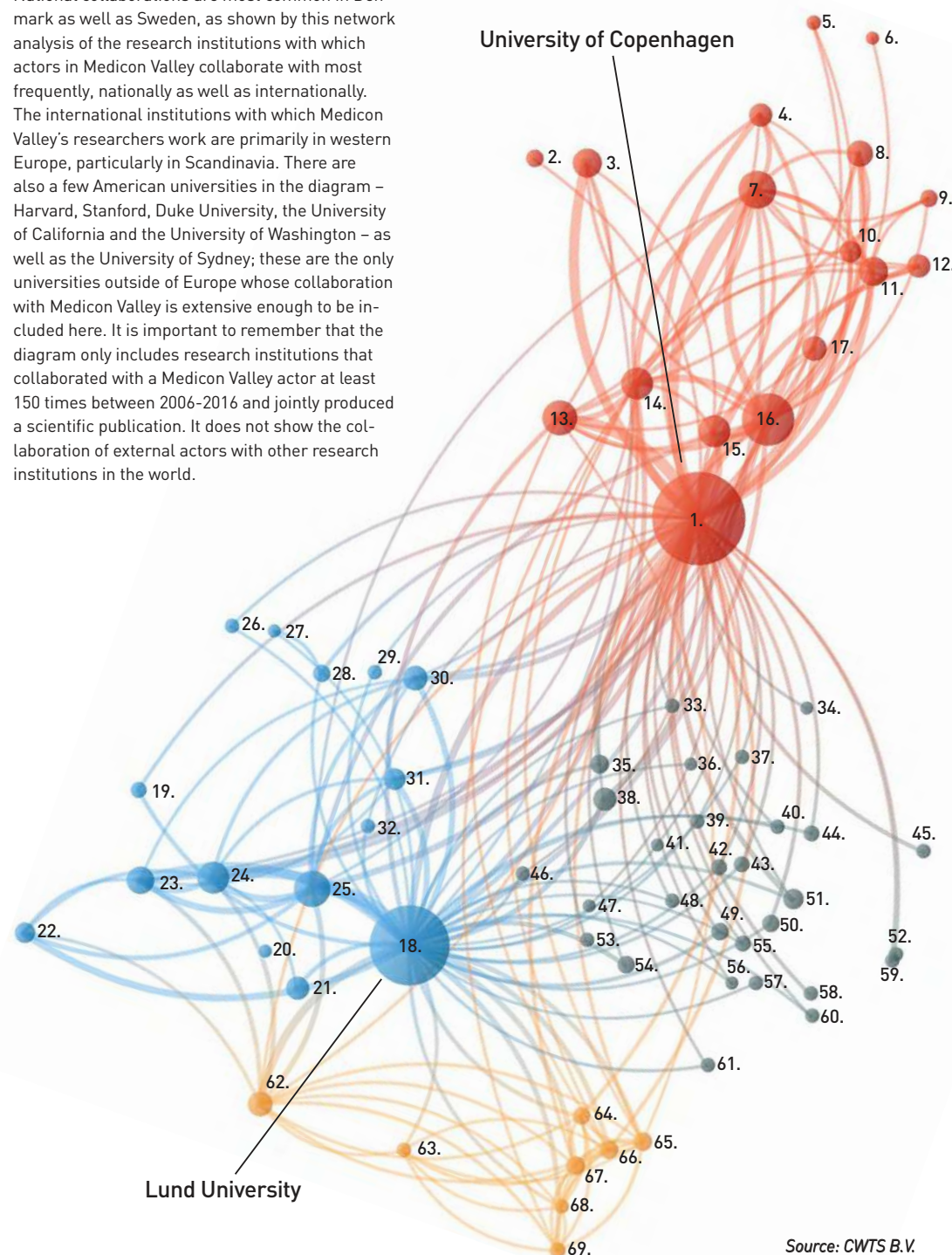
In all clusters, publications produced in international collaborations are more frequently cited than those that have come forth in national collaborations or no collaboration. The MNCS score for publications based on international collaborations is generally 1.8-1.9, whilst the other articles are usually around 1-1.1, with few exceptions – particularly London-Cambridge-Oxford and the Netherlands.



For each cluster, the diagram shows the share of the output produced by individual researchers/research institutions (grey), via a national research collaboration (red), and through international research collaboration (blue); and the degree to which these publications are cited in relation to the mean normalised citation score for their respective fields of research (MNCS). The number 1 indicates that a published article has been cited as often as the calculated normal average in its field of research.

INTERNATIONAL COLLABORATIVE PARTNERS IN THE LIFE SCIENCES (2006-2016)

National collaborations are most common in Denmark as well as Sweden, as shown by this network analysis of the research institutions with which actors in Medicon Valley collaborate with most frequently, nationally as well as internationally. The international institutions with which Medicon Valley's researchers work are primarily in western Europe, particularly in Scandinavia. There are also a few American universities in the diagram – Harvard, Stanford, Duke University, the University of California and the University of Washington – as well as the University of Sydney; these are the only universities outside of Europe whose collaboration with Medicon Valley is extensive enough to be included here. It is important to remember that the diagram only includes research institutions that collaborated with a Medicon Valley actor at least 150 times between 2006-2016 and jointly produced a scientific publication. It does not show the collaboration of external actors with other research institutions in the world.



Source: CWTS B.V.

RED

The Danish research institutions

1. University of Copenhagen
2. Roskilde University
3. Technical University of Denmark
4. Aalborg University
5. Roskilde Hospital
6. Hillerød Hospital
7. University of Southern Denmark
8. Herlev Hospital
9. Frederiksberg Hospital
10. Gentofte Hospital
11. Bispebjerg Hospital
12. Hvidovre Hospital
13. Aarhus University
14. Aarhus University Hospital
15. State Serum Institute
16. Rigshospitalet
17. Glostrup Hospital

BLUE

Most of the Swedish institutions as well as the Scandinavian institutions

18. Lund University
19. Swedish University of Agricultural Sciences
20. Kristianstad University
21. Malmö University
22. Linköping University
23. Uppsala University

24. University of Gothenburg
25. Karolinska Institute
26. Norwegian University of Science and Technology
27. Haukeland University Hospital
28. University of Bergen
29. University of Iceland
30. University of Oslo
31. University of Helsinki
32. University of Turku

GREY

International research institutions that collaborate with both Swedish and Danish institutions

33. Duke University
34. University of Sydney
35. National Institutes of Health
36. University of California SF
37. University of Toronto
38. Harvard University
39. University of Manchester
40. Maastricht University
41. King's College London
42. VU University Amsterdam
43. Erasmus University Rotterdam
44. Leiden University
45. Max Planck Society
46. University of Washington Seattle
47. University of Bern

48. University of Groningen
49. Katholieke Universiteit Leuven
50. University of Amsterdam
51. University College London
52. Humboldt-Universität zu Berlin
53. Ghent University
54. Stanford University
55. Radboud University Nijmegen
56. Ludwig-Maximilians Universität München
57. Heidelberg University
58. University of Zürich
59. Freie Universität Berlin
60. University of Milan
61. French Institute of Health and Medical Research

YELLOW

International research institutions that primarily collaborate with the Swedish institutions

62. Umeå University
63. The Arctic University of Norway
64. University of Cambridge
65. Utrecht University
66. Imperial College London
67. University of Oxford
68. National and Kapodistrian University of Athens
69. German Cancer Research Center

Network analysis of Medicon Valley's international collaboration

- The graphic shows collaborations in the life sciences between research institutions in Sweden and Denmark (at least one of which is located in Medicon Valley) that led to publications between 2006-2016. A minimum of 150 instances of collaboration is required for an institution to be included in the graphic. The thickness of the lines and dots shows the collaboration volume – the larger the dot or the thicker the line, the greater the number of collaborations.
- The colours are generated automatically in the computer program VOSViewer, which classifies groups or networks of research institutions with more frequent joint collaborations. The Danish research institutions are shown in red, while most of the Swedish institutions as well as the Scandinavian institutions are in blue. The (usually) international research institutions that are in a network with closer connections to the Swedish institutions are in yellow, and in grey are the international research institutions that have as many connections to both Swedish and Danish institutions.

countries, says DTU's Dean of Research Katrine Krogh Andersen.

The large research facilities European Spallation Source, ESS, and Max IV, currently being built and completed, respectively, on the outskirts of Lund, are also expected to attract many international researchers to the region. The region's universities both hope and believe that this will lead to a major increase in international collaboration.

On the whole, the research collaborations with countries outside of Europe are few. Very few research institutions outside of Europe have collaborated closely enough with a partner in Medicon Valley

to have co-authored at least 150 publications in the life sciences since 2006, according to a network analysis conducted by CWTS.

The colours on the map are automatically assigned by the computer program based on which networks have the greatest number of internal connections, and in this case they show that the research networks are predominantly national, followed by European, although Harvard and Stanford also appear on the map. The Swedish network has such close connections to the Nordic educational institutions that they have also been assigned the same colour – blue – whilst the red network comprises only Danish research institutions.

THE NATIONAL NETWORKS ARE STRONGEST – BUT THE UNIVERSITIES WANT MORE TRANS-ØRESUND COLLABORATION

Internal research networks in Sweden and Denmark are markedly stronger than the ones that cross the Øresund Strait, shows CWTS' network analysis of the Swedish and Danish research institutions with which Medicon Valley actors collaborate in the life sciences. Although practical issues and border obstacles throw a spanner in the works, the universities in Medicon Valley believe that more trans-Øresund cooperation would strengthen research. New research facilities and a joint strategy for diabetes are brought forth as ways to draw the region closer together.

The national networks and the connections between research institutions, particularly in Denmark, are much more closely intertwined than the ones that cross the Strait. In its analysis, CWTS writes: "It looks like Copenhagen University is more firmly locked in national collaboration than its Swedish counterpart" – i.e. Lund University. But Skåne is also part of a national network that is significantly stronger than the one that crosses the border to Denmark. On the network map (see the following pages), this can be seen from the compact bunch of lines within each country's national borders, whilst the lines that connect the countries are thinner.

According to the Pro Vice-Chancellor of Lund University Bo Åhrén, a probable explanation for the nationally focused networks is related to the national education and research structures.

– There are doubtless a lot of explanations, but the career structures are thus that people build up their careers within national boundaries and have their networks there. Grants are also oftentimes national, and it can be difficult to transfer them if one moves to the other country, he says.

Accent on Øresund collaboration

The University of Copenhagen and Lund University are the two research institutions in the respective countries with the greatest number of collaboration links to other actors, both national and international, in CWTS' network analysis. They are responsible for many of the trans-Øresund collaborations.

The colours and standing of each research institution on the network map are generated automatically by the computer program VOSViewer and based on the groupings with particularly many collaborations. It should be noted that the Danish State Serum Institute is shown in blue – it has such a large number of collaborations with Swedish actors that the computer program has situated it

in the Swedish network. In addition, an "independent" network has been generated in Denmark with a smaller number of research institutions that often collaborate internally. DTU and Roskilde University are both part of that network.

All of the research institutions in Medicon Valley have co-produced at least 20 scientific publications in the life sciences with an actor from the other side of the Strait between 2006-2016 – this is a requirement in order for a line to appear between the research institutions. Some have only a few lines leading to their neighbouring country; such is the case with Roskilde University, Kristianstad University, and Copenhagen Business School (CBS), whilst others – e.g. DTU, Malmö University and the Swedish University of Agricultural Sciences – have a somewhat greater amount. There is also a great deal of collaboration between the region's hospitals – read more on pages 48-49.

The network analysis does not only show internal collaboration within Medicon Valley, but also the collaboration of Medicon Valley-based research actors with actors in all of Sweden and Denmark.

The Dean of Research at DTU Katrine Krogh Andersen emphasises the importance of collaboration with all of Scandinavia.

– Working internationally, one often sees that Scandinavia is capable of a lot together. We have a great deal of culture in common and a shared access to things; that often makes collaboration very simple and straightforward. That's one area where we could do more in terms of research than we're doing today, she says.

All of the university representatives interviewed are of the opinion that there is a lot to be won from expanding collaboration in Medicon Valley specifically. The University of Copenhagen – which is the region's largest research institution and on the whole the university in Medicon Valley that places

highest on international ranking lists – has perhaps the most lukewarm attitude when it comes to trans-Øresund collaboration. Its representatives see the proximity to Skåne as the only real advantage, as well as the possibility to create a profile as a cluster.

– Everyone talks about Silicon Valley. Without making direct comparisons, one might ask: How can we make Medicon Valley a magnet that attracts the best minds, the world's greatest talents? We have an opportunity to join together as a cluster to make ourselves appealing and attract researchers, funding and businesses, says Erik Bisgaard Madsen, Vice Dean for Public and Private Sector Services at the University of Copenhagen's Faculty of Science.

His colleague at the university, Vice Dean for Innovation and External Relations at the Faculty of Health and Medical Sciences Trine Winterø, maintains that the proximity across the strait is an important factor.

– The largest competitive advantage we have is actually the proximity principle – we can meet within an hour; that just isn't possible with someone in Munich, for example, she says.

The other university representatives, particularly the Swedish ones, are more enthusiastic.

– It's important to strengthen the cooperation between Lund, Malmö and Copenhagen. There is unexploited potential, and international collaborations improve research quality, says Bo Åhrén.

Three suggestions for action

There are three recurrent suggestions for how to increase the common efforts across the Øresund that come from practically all of the university representatives. The first concerns joint educational training over the strait, especially as a way for budding researchers to meet and create networks.

– Networks emerge between professors and former students, and people who know each other because they've already established a professor-student relationship have an easier time working together. To expand transborder collaboration, educational training could take place across the Danish-Swedish border, taking advantage of the fact that there are strong universities on both sides, says Erik Bisgaard Madsen.

Another suggestion regards allocating research funds specifically for Øresund collaborations; according to some of the university representatives this is also a way to steer the research being performed.

– Virtually all research today has external funding, so starting it up would require research funds, says Katrine Krogh Andersen from DTU.

The third way put forth to increase collaboration

in Medicon Valley is via transdisciplinary meeting places and conferences. This is already happening on smaller scale, but the university representatives interviewed believe that the frequency could increase.

– Meeting places can be arranged where researchers from the University of Copenhagen and others from the Swedish side of the strait can be brought together, and the possibilities for interaction that exist can be made more visible, says Mogens Holst Nissen, Vice Dean of Research at the Faculty of Health and Medical Sciences at the University of Copenhagen.

Vice Chancellor of Malmö University Kerstin Tham has more concrete suggestions concerning joint meetings across the border. She wants to bring together all of Medicon Valley in a common life science strategy, for instance in diabetes, where the Danish and Swedish sides both conduct comprehensive and flourishing research, in order to create a stronger national and international profile for the region. A strategy like that could be presented at a joint symposium, she says.

– One way to get started with a strategy in Medicon Valley for e.g. diabetes would be to hold a symposium in Brussels together with the businesses. I think it's important to start with something concrete, she says.

By holding the meeting in Brussels, the strategy also becomes associated to the EU, says Kerstin Tham, who hopes to get Danes and Swedes to work together more. She emphasises that Danish universities have been very good at applying for research funding from the EU; she believes that both sides of the Øresund would benefit if learning institutions in Sweden could climb on board.

– For us to grow stronger, it would be valuable to support each other in these issues, she says.

Different regulations create difficulties

Although the university representatives agree that more Danish-Swedish cooperation would be a good thing, implementing that is not always easy from a practical point of view. This is due in part to how the transborder region works pragmatically.

– If we are analysing it as a region, we also need to see that there are certain issues that have yet to be resolved; and then there's this situation with problems with everything from passport checks to unemployment benefits, to commuting back and forth, says Trine Winterø from the University of Copenhagen.

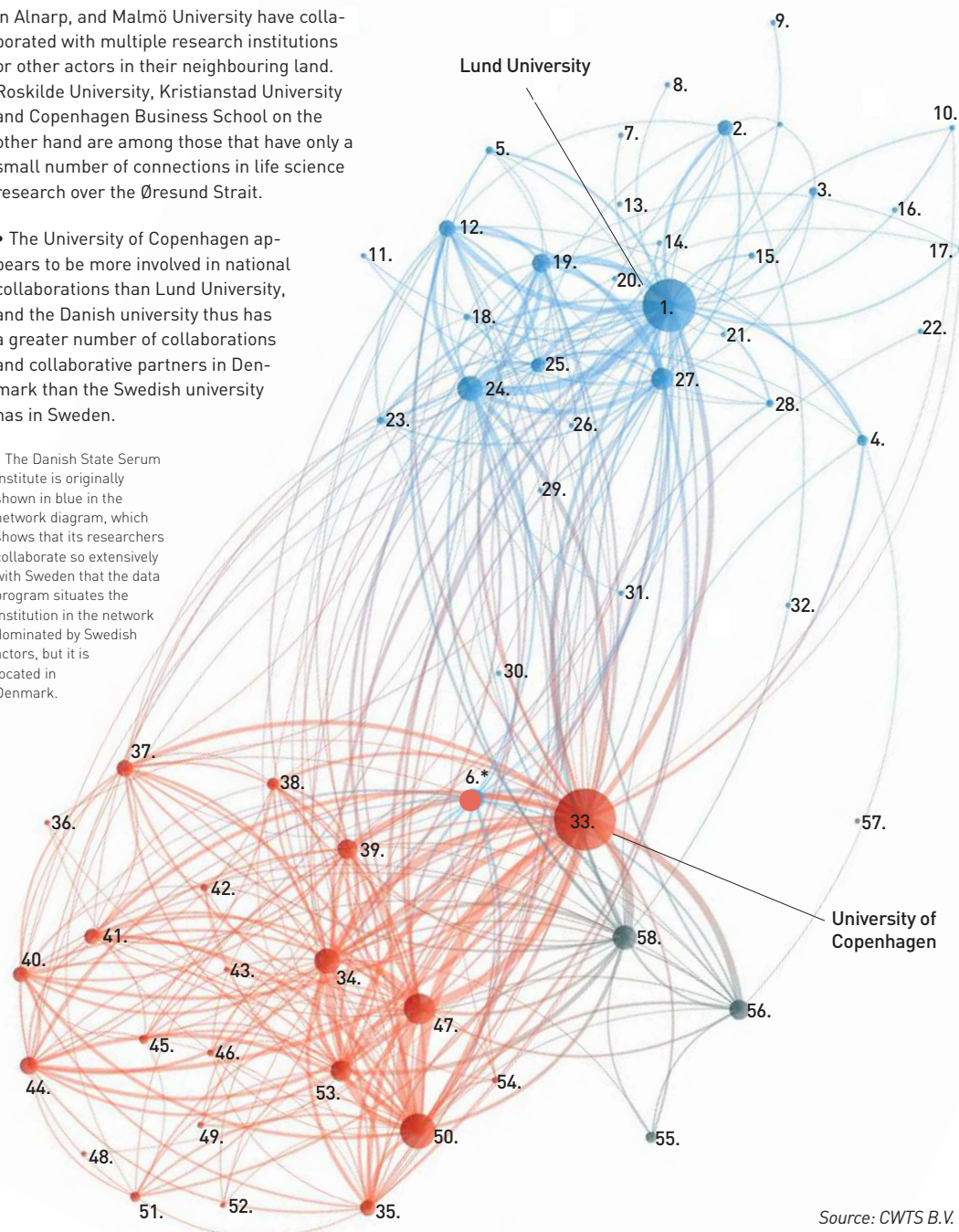
She also underscores that the region has to reconcile two currencies and two train systems, as well as national regulations in two different countries.

SWEDISH AND DANISH COLLABORATIVE PARTNERS IN THE LIFE SCIENCES (2006-2016)

- Trans-Øresund collaborations are significantly less extensive than those within the national boundaries according to this network analysis, which focuses solely on Swedish and Danish research institutions that have had a minimum of 30 collaborations that resulted in publications between 2006-2016. There is however a relatively high degree of collaboration between the University of Copenhagen and Lund University, as well as a high volume of collaborations with research actors in the other country. The Technical University of Denmark, the Swedish University of Agricultural Sciences in Alnarp, and Malmö University have collaborated with multiple research institutions or other actors in their neighbouring land. Roskilde University, Kristianstad University and Copenhagen Business School on the other hand are among those that have only a small number of connections in life science research over the Øresund Strait.

- The University of Copenhagen appears to be more involved in national collaborations than Lund University, and the Danish university thus has a greater number of collaborations and collaborative partners in Denmark than the Swedish university has in Sweden.

* The Danish State Serum Institute is originally shown in blue in the network diagram, which shows that its researchers collaborate so extensively with Sweden that the data program situates the institution in the network dominated by Swedish actors, but it is located in Denmark.



Source: CWTS B.V.

BLUE

Swedish research institutions in Medicon Valley

1. Lund University
2. Malmö University
3. Kristianstad University
4. Swedish University of Agricultural Sciences
5. Helsingborg Hospital
- See below for number 6.

Other Swedish research institutions

7. Halmstad University College,
8. Karlstad University,
9. Luleå University of Technology,
10. Chalmers University of Technology,
11. Skaraborg Hospital,
12. Umeå University,
13. University College of Borås,
14. Jönköping University,
15. Linneaus University,
16. Royal Swedish Academy of Science,
17. KTH Royal Institute of Technology,
18. Örebro University,
19. Uppsala

University, 20. Skövde University College, 21. Mid Sweden University, 22. Swedish Museum of Natural History, 23. Örebro University Hospital, 24. Karolinska Institute, 25. Linköping University, 26. Läns-sjukhuset Ryhov, 27. University of Gothenburg, 28. Stockholm University, 29. National Board of Health and Welfare, 30. European Centre for Disease Prevention & Control Sweden, 31. Public Health Agency of Sweden, 32. Swedish National Veterinary Institute

RED AND GREY

Danish life science research institutions in Medicon Valley

33. University of Copenhagen
34. University of Southern Denmark
35. Aalborg University
36. Amager Hospital
37. Glostrup Hospital

38. Frederiksberg Hospital
39. Bispebjerg Hospital
40. Gentofte Hospital
41. Hvidovre Hospital
42. Holbæk Hospital
43. Køge Hospital
44. Herlev Hospital
45. Hillerød Hospital
46. Slagelse Hospital
47. Copenhagen University Hospitals
48. Nykøbing Hospital
49. Næstved Hospital
50. Rigshospitalet
51. Roskilde Hospital
55. Roskilde University
56. Technical University of Denmark
57. Copenhagen Business School
- 6.* State Serum Institute

Other Danish research institutions

52. Lillebælt Hospital,
53. Aarhus University Hospital,
54. Skejby Hospital,
58. Aarhus University

Network analysis of Medicon Valley's cooperation with the whole of Sweden and Denmark

- The graphic shows collaborations in the life sciences between research institutions in Sweden and Denmark (at least one of which is located in Medicon Valley) that have led to publications. A minimum of 30 instances of collaboration is required for an institution to be included in the graphic. The thickness of the lines shows the collaboration volume – the thicker the line, the greater the number of collaborations. The absence of lines to research institutions indicates that the number of collaborations is too low for the program that generated the graphic to show them.
- The colours are generated automatically in the computer program VOSViewer, which classifies groups or networks of research institutions with more frequent joint collaborations. Swedish research institutions are shown in blue, and most of the Danish ones are in red; however, one group of Danish research institutions forms its own, grey network group. The Danish State Serum Institute is shown in blue in the network diagram, which shows that its researchers collaborate so extensively with Sweden that the data program situates the institution in the network dominated by Swedish actors.
- It is important to note that Copenhagen University Hospitals is the name of a collaboration between the University of Copenhagen and a number of hospitals in the Capital Region of Denmark and Region Zealand; it does not refer to an independent research actor.

The latter of these creates a series of obstacles, regarding research funding, among other things. Different rules and regulations also make it difficult to formulate a joint research training – as a number of the university representatives have suggested; research training lasts three years in Denmark and four years in Sweden.

– Joint research training projects aren't really a possibility, because there are two different systems; so it has to be done differently – with joint research projects where doctoral students can be linked to

either one of the universities, but even then, there are certain administrative obstacles, says Bo Åhrén.

Research facilities bring the region together

There is one thing that has already begun drawing the Danish and Swedish sides of Medicon Valley closer together: the research facilities ESS and MAX IV.

– When it comes to ESS in the region there's a whole lot of focus on the life sciences, and I think that many very exciting things are going to happen there, says Katrine Krogh Andersen from DTU.

MORE DANISH HOSPITALS WITH CLINICAL RESEARCH THAN SWEDISH

More life science research is being conducted at a greater number of hospitals on the Danish side of the Øresund Strait; on the Swedish side, it is concentrated at Skåne University Hospital. This can be seen in CWTS' network analysis of which actors in Sweden and Denmark research institutions in Medicon Valley collaborated with from 2006-2016, with a particular focus on hospitals.

This network analysis differs from the one on the previous pages in that Skåne University Hospital has been separated from Lund University. The vast majority of the research at Skåne University Hospital is labelled as Lund University in the database Web of Science used by CWTS; for this reason, the hospital does not appear as an independent actor in the network analysis if it is not actively highlighted – as it is here.

In this version of the network analysis, the strong connections between the hospitals in Skåne and other hospitals in Sweden are also noticeable. Together with several individual universities, they form a network of their own, shown here in orange. The Danish network is red, and the rest of the Swedish network, mainly comprising learning institutions, is blue. The networks and their colours are automatically generated in the computer program.

Noticeable is that research in Denmark is dispersed in a significantly larger number of hospitals than in Sweden, at least in Medicon Valley. For example, Rigshospitalet, Hvidovre Hospital, Bispebjerg Hospital, Herlev Hospital and Gentofte Hospital are marked with rather large dots on the map, which indicates ample research and collaboration. The umbrella organisation Copenhagen University Hospitals is visible in the network analysis as an independent actor, although it does not conduct research of its own; instead it is a collaborative effort between the hospitals in the Capital Region of Denmark, Region Zealand, and the University of Copenhagen.

The only hospitals in Skåne on the map are Skåne University Hospital in Lund and Malmö and Helsingborg Lasarett.

Rising number of clinical studies in Denmark

There are no conclusive answers as to exactly why this structural differentiation has emerged, but one influential factor is that the Danish part of Medicon Valley is a geographically larger area than the Swedish part, and also part of a capital region.

On the whole, the number of clinical studies is

declining in Europe, but both Denmark and Sweden are making investments to increase them in their respective countries. Denmark also successfully turned around the downward trend in the early 2010s, and the number of clinical studies – commercial as well as non-commercial – continues to rise, as a 2017 report from the Danish Medicines Agency shows. On the contrary, in Sweden, developments in clinical studies are at a standstill, as statistics from the Swedish Medical Products Agency show.

According to Olle Ljungqvist, former chairperson of the Danish research council Det Strategiske Forskningsråds programkomite for individ, sygdom og samfund, who is now Professor of Surgery at Örebro University, clinical research is prioritised more highly in Denmark than in Sweden.

– One important reason that Sweden isn't keeping up in research is that there is no time – not even at the university hospitals. Even if the research funds are there, there is no time because there is clinical work that needs to be done. Danes have been very good at that. They have been intelligent in giving large grants to research units that have built up networks and gathered around specific issues; so they have been able to build up very strong research that is close to patients, he says.

Medical training can make a difference

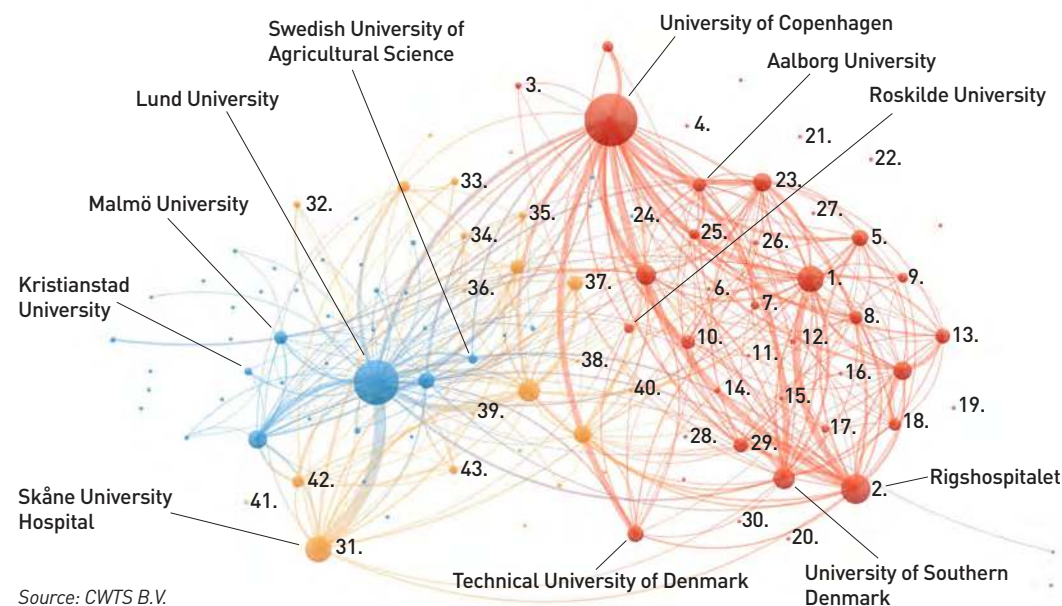
According to Bo Ahrén, Pro Vice-Chancellor at Lund University, the structural differences between the Danish and Swedish sides of Medicon Valley are also noticeable in that medical training in Skåne is concentrated at Skåne University Hospital, whilst it is more broadly distributed in Copenhagen.

– A doctor or nurse at a smaller hospital who is interested in research needs to have a collaboration. But if it was part of the university, and there were students coming there all of the time, and there were instructors and other research done at the hospital, then of course there would be more, he says.

On the whole, Bo Ahrén would also like to see larger grants for clinical research in Sweden.

SWEDISH AND DANISH COLLABORATIVE PARTNERS IN THE LIFE SCIENCES (2006-2016), INCLUDING UNIVERSITY HOSPITALS

On the Danish side of the Øresund Strait, research collaborations often take place between a significantly greater number of hospitals, often under the umbrella term "Copenhagen University Hospitals", than is the case on the Swedish side. In Sweden, clinical research is largely concentrated in Skåne University Hospital.



Source: CWTS B.V.

RED

Danish hospitals in Medicon Valley

1. Copenhagen University Hospitals
2. Rigshospitalet
3. Holbæk Hospital
4. Ringsted Hospital
5. Bispebjerg Hospital
6. Helsingør Hospital
7. Roskilde Hospital
8. Hvidovre Hospital
9. Frederiksberg Hospital
10. Glostrup Hospital
11. Nykøbing Hospital
12. Næstved Hospital
13. Herlev Hospital
14. Slagelse Hospital
15. Køge Hospital

Other Danish hospitals

16. Amager Hospital
17. Hillerød Hospital
18. Gentofte Hospital
19. Frederikssund Hospital
20. Bornholm Hospital
21. Aarhus County Hospital,
22. Marselisborg Hospital,
23. Aarhus University Hospital,
24. Aalborg Psychiatric Hospital,
25. Aalborg University Hospital,
26. Skejby Hospital,
27. Risskov Psychiatric Hospital,
28. Svendborg Hospital,
29. Odense University Hospital,
30. Lillebælt Hospital

BLUE AND ORANGE

Swedish hospitals in Medicon Valley

31. Skåne University Hospital
32. Helsingborg Hospital

Other Swedish hospitals

33. Linköping University Hospital,
34. Örebro University Hospital,
35. University Hospital of Umeå,
36. Skaraborg Hospital,
37. Karolinska University Hospital,
38. Danderyds Hospital,
39. Länssjukhuset Ryhov,
40. St Erik's Eye Hospital,
41. Queen Silvia's Children's Hospital,
42. Sahlgrenska University Hospital,
43. Uppsala University Hospital

Network analysis including hospitals

Like the one on page 46, this graphic also shows collaborations in the life sciences between research institutions in Sweden and Denmark (at least one of which is located in Medicon Valley) that have led to publications. Here a minimum of 20 collaborative instances is required for a line to show in the graphic. This time however, the university hospitals are treated as independent institutions, although they have often been registered in Web of Science as subcategories to a university, to show the role that they play in the network.

UNIVERSITIES, REGIONS AND RESEARCH INSTITUTIONS

PHOTO: NEWS ØRESUND



1. REGION ZEALAND*

Life science researchers: 520
of which professors: 21
of which doctoral students: 110
Life science students: -

PHOTO: NEWS ØRESUND



2. ROSKILDE UNIVERSITY

Life science researchers: 55
of which professors: 6
of which doctoral students: 19
Life science students: 459

PHOTO: NEWS ØRESUND



3. TECHNICAL UNIVERSITY OF DENMARK (DTU)

Life science researchers: 760
of which professors: 59
of which doctoral students: 259
Life science students: 2 424

PHOTO: NEWS ØRESUND



4. UNIVERSITY OF COPENHAGEN

Life science researchers: 5 206
of which professors: 598
of which doctoral students: 2 530
Life science students: 15 393

PHOTO: NEWS ØRESUND



5. THE NATIONAL INSTITUTE OF PUBLIC HEALTH (NIPH), UNIVERSITY OF SOUTHERN DENMARK

Life science researchers: 106
of which professors: 8
of which doctoral students: 13
Life science students: 0

PHOTO: NEWS ØRESUND



6. REGION HØVEDSTADEN*

Life science researchers: 3 832
of which professors: 225
of which doctoral students: 818
Life science students: -



Source: The universities themselves.

Life science researchers includes professors, associate professors, lecturers, post docs, doctoral students, etc. See footnotes in the Appendix for more information about the figures.

* Researchers at the hospitals in the region often conduct research part-time. Some of the researchers at the hospitals and at the Danish Cancer Society also have part-time positions at the University of Copenhagen or Lund University.

**The numbers for Lund University are not complete.

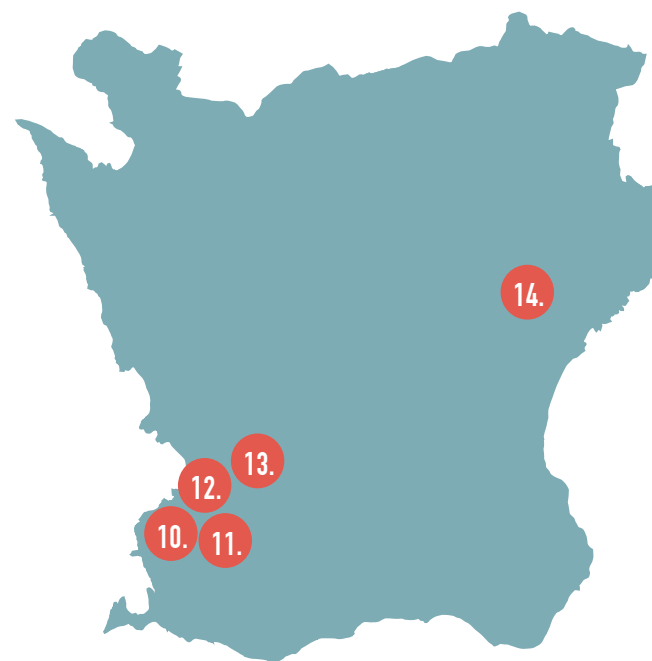


PHOTO: NEWS ØRESUND



7. AALBORG UNIVERSITY IN COPENHAGEN

Life science researchers: 24
of which professors: 4
of which doctoral students: 6
Life science students: n.a.

PHOTO: NEWS ØRESUND



8. STATE SERUM INSTITUTE

Life science researchers: 130
of which professors: n.a.
of which doctoral students: n.a.
Life science students: -



9. DANISH CANCER SOCIETY*

Life science researchers: ca 250
of which professors: 11
of which doctoral students: 51
Life science students: -



10. MALMÖ UNIVERSITY

Life science researchers: 120
of which professors: 30
of which doctoral students: 80
Life science students: ca 2 000



11. REGION SKÅNE*

Life science researchers: ca 1 800
of which professors: 113
of which doctoral students: 754
Life science students: -



12. THE SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCE IN ALNARP

Life science researchers: 171
of which professors: 20
of which doctoral students: 45
Life science students: 409



13. LUND UNIVERSITY**

Life science researchers: 1 617
of which professors: 241
of which doctoral students: 1 049
Life science students: ca 2 800



14. KRISTIANSTAD UNIVERSITY

Life science researchers: 50
of which professors: 7
of which doctoral students: 8
Life science students: 500

THE UNIVERSITY OF COPENHAGEN WANTS BETTER CONDITIONS FOR COOPERATION

Research conducted at the University of Copenhagen lifts Medicon Valley in the bibliometric comparison with nine other life science clusters in Europe, say three of the university's vice deans, Erik Bisgaard Madsen, Mogens Holst Nissen and Trine Winterø. But for results that are better still, they advocate more Danish-Swedish collaboration – and for that to work, fewer border obstacles and smoother travel throughout the region.

International research collaborations are important for improving the quality of research in Medicon Valley and at the University of Copenhagen, and for broadening its reach, says Erik Bisgaard Madsen, Vice Dean for Public and Private Sector Services at the Faculty of Science. One way to strengthen the area would be to increase cooperation across the Øresund Strait, he says. That would also attract more international researchers to the region.

He also points out the importance of collaboration with the commercial sector.

– Everyone talks about Silicon Valley. Without making direct comparisons, one might ask: How can we make Medicon Valley a magnet that attracts the best minds, the world's greatest talents? We have an opportunity to join together as a cluster to make ourselves appealing and attract researchers, funding and businesses, he says, drawing a parallel to the field of food, where he maintains that the Danish cluster is among the world's three most successful.

– There has been close collaboration between the food sector and universities in Denmark for 50 years – both in terms of education and research – and there is a constant effort to strengthen that collaboration, he says.

Personal networks stimulate collaboration

To enhance collaboration between the Swedish and Danish parts of Medicon Valley, Erik Bisgaard Madsen believes it would be intelligent to start with students and try to create joint educational training; that would also resonate with researchers, who could meet and expand their personal networks – according to the three vice deans, this is one of the two most important factors for getting increased collaboration to really take off.

– People who know each other because they've already established a professor-student relationship

have an easier time working together, says Erik Bisgaard Madsen.

The second factor entails additional resources to facilitate collaboration, says Erik Bisgaard Madsen, for example reimbursement for travel and other costs.

His colleagues at the Faculty of Health and Medical Sciences, the Vice Dean for Innovation and External Relations Trine Winterø and the Vice Dean for Research Mogens Holst Nissen, believe

that conscious efforts are necessary to develop more comprehensive trans-Øresund cooperation in life science research, and more meeting points, courses and conferences could be means to reach this end.

But he and Trine Winterø agree that the single, foremost factor motivating that the universities in Zealand and Skåne collaborate with each other and not with other universities around the world is

their geographic proximity. But that is under threat due to incomprehension on a political level, border obstacles, and infrastructure that does not work, says Trine Winterø.

– The greatest advantage we have is actually the proximity principle – we can meet within an hour; that just isn't possible with someone in Munich, for example. But when there are border controls, and then train traffic is at a standstill... she says, and begins to laugh.

Substantial incoming research grants

Usually, the University of Copenhagen is the centre of learning in Medicon Valley that is placed highest on international ranking lists that evaluate everything from scientific publications and international reputation to student-to-staff ratio, and the three vice deans see the research at their respective faculties as an important contribution to the region's overall position.

– An internal analysis was done by the Copenhagen University Library that shows that 20% of

"The largest advantage we have is actually the proximity principle – we can meet within an hour."



Erik Bisgaard Madsen, Trine Winterø and Mogens Holst Nissen, three of the university's vice deans.

the publications from the University of Copenhagen belong to the 10% most frequently cited of all publications, says Mogens Holst Nissen.

That study – using the source SciVal, which builds on data from the citation index Scopus – is not directly comparable with the CWTS analysis however, which examines solely the life sciences and builds on Web of Science.

Mogens Holst Nissen points out that the university has received substantial funding for life science research from e.g. the Novo Nordisk Foundation, the Lundbeck Foundation and the Danish National Research Foundation, as well as EU funding.

– That has been highly significant for the success we've had. The University of Copenhagen has been able to attract sizeable external grants, even in situations where the public institutions are facing demands from the State to lower costs by two per cent annually, he says.

According to Mogens Holst Nissen, a long-term perspective on the development of research is important – for that reason, he also sees it as positive that the total number of publications in the region increased steadily throughout the period studied, 2006-2016. Other than that, he finds that the results of the bibliometric comparison are more or less what one might expect.

– Seen in its context and with the investments made in Medicon Valley, we are satisfied with the level we're at now. Because if we look at how our research is being cited and the impact it has, we see it as having successfully filled a quality criterion, he says.

All three of the vice deans emphasise, however, that a bibliometric comparison only shows one aspect of reality; the number of publications and citations needs to be interpreted according to the particular circumstances of a region, including eve-

rything from the number of headquarters located there to differences in currency.

Diabetes and cancer – major research areas

Looking at the University of Copenhagen specifically, it is a centre of learning with many thriving research areas in the life sciences, often linked to research centres.

Among the most important areas are those concerning metabolic disorders and diabetes, and cancer. Two important research centres in these respective areas are the Novo Nordisk Centre for Basic Metabolic Research (CBMR) and the Biotech Research & Innovation Centre (BRIC).

In the field of medicine, the university also highlights neuroscience – particularly in relation to disorders such as dementia, Alzheimer's and Parkinson's disease, as well as public health sciences in register research and epidemiological research. Some important centres with successful research are the Novo Nordisk Foundation Center for Protein Research, with research on cell growth and the role that proteins play in it; and the Centre for Chromosome Stability, in particular regarding research on chromatin and DNA damage.

In the natural sciences, genomics and metagenomics, as well as plant science and bioinformatics, are among the best in the world, according to the university. Other strong research environments are in structural biology, muscle physiology and work physiology. There are also a number of thriving research centres at the Faculty of Science, e.g. the Centre for Bacterial Stress Response and Persistence (BASP), with basic research on microbial resistance and the relationship between micro-organisms and antibiotics; both of the plant research centres the Center for Dynamic Molecular Interactions (DynaMO) and Copenhagen Plant Science Centre, as well as the Center for Stem Cell Decision Making.

MEDICON VALLEY'S POTENTIAL NOT BEING USED TO THE FULLEST, SAYS PRO VICE-CHANCELLOR

Over the past 20 years, the Danish side of Medicon Valley has outperformed the Swedish side on international ranking lists and bibliometric comparisons. One important explanation is that the large life science companies in Copenhagen have stayed there and flourished, while AstraZeneca left Lund, says Pro Vice-Chancellor of Lund University Bo Ahrén. But Denmark's successes also benefit Skåne, he says, and he is pleased with Medicon Valley's placement on CWTS' comparative analysis.

– When we formed Medicon Valley in the 1990s, publication output was more or less the same on both sides of the Øresund Strait. The difference has grown large. It's not that Skåne has declined; it's that Copenhagen has had very strong development and progressed even further, says Bo Ahrén, who is also the former chairperson of Medicon Valley Alliance.

Large life science companies like Novo Nordisk and Lundbeck stayed in Copenhagen, while AstraZeneca shut down its operations in Lund – he sees this as part of the explanation. Another part is the fact that size itself is an attractive factor. Copenhagen is a capital city, and Lund and Skåne are ultimately outlying districts in Sweden.

– But increases on the Danish side are by no means negative; they also benefit Skåne. And we have strong universities here as well. The University of Copenhagen and Lund University are both located within such a small area, and both rank highly internationally he says.

In CWTS' bibliometric comparison of ten life science clusters in Europe, the significant increase in scientific publications in Medicon Valley is what Bo Ahrén wants to highlight most of all. And on the whole, he considers the results to be very good.

– Research impact is at a high level, and it remains high although the number of scientific publications has increased, which is good. It's not that multiple publications are being produced for the same research; in that case the impact would have dropped, he says.

ESS and MAX IV expected to boost collaboration

To continue strengthening research in the entire region, Bo Ahrén says, it is important to invest in

international collaboration in the rest of the world as well as between the Danish and Swedish parts of the region.

– When the Øresund Bridge was built, the hope was that research collaboration would increase – and it has increased. But perhaps its potential isn't being used to the fullest.

One problem is the administrative obstacles that come from the region being in two different

nations. Bo Ahrén uses the fact that the Swedish research training lasts four years, whilst the Danish lasts three as an example.

– Joint research training projects aren't really a possibility, because there are two different systems; so it has to be done differently – with joint research projects where doctoral students can be linked to either one of the universities, but even then,

there are certain administrative obstacles, he says.

Another barrier that he points out concerns career paths, which are usually national. As a result, the contact networks that researchers have created are often limited by national borders instead of extending over the Strait. These networks are then maintained by e.g. national meetings for subject areas.

According to Bo Ahrén, the tendency is reinforced further by research grants that are often national, making it easier for researchers to move between universities in the country where they are located than to cross the border.

An impetus to overcome these difficulties could be the materials research facilities European Spallation Source, ESS, and MAX IV, he says. ESS, which is being built in Lund and has its data centre in Copenhagen, has both Swedish and Danish hosts, whilst MAX IV belongs to Lund University.

"When the Øresund Bridge was built, the hope was that research collaboration would increase – and it has increased. But perhaps its potential isn't being used to the fullest."



On the whole, Bo Ahrén considers Medicon Valley's results in CWTS' bibliometric comparison to be very good.

A great deal of the research at both facilities is expected to be in the life sciences.

– That will attract Danish researchers and lead to increased internationalisation and increased collaboration with Denmark on contemporary subjects, says Bo Ahrén.

Attracting researchers with nearness to nature

Another internationalisation-related issue that unites the Swedish and Danish parts of the region concerns attracting talents to Medicon Valley. In the competition with other European life science clusters, it's important to create a good environment that will make people want to come to Medicon Valley, says Bo Ahrén.

– It's important to attract international talents who will stay here, and that there is a recruitment policy in place to make that possible. That places requirements on the nations as well as the centres of learning. There need to be homes, international schools for the children – everything needs to work. That's not as easy as it sounds. For researchers who take the jump, it's not so simple. It also requires good backing for the person with the research grant from the start, as getting into the national programmes is not easy, he says.

But Bo Ahrén also believes that Medicon Valley has positive things to offer, with short distances and its proximity to nature.

– It's possible to have a more positive lifestyle here and still be close to almost everything, thanks to Kastrup.

Where the region places in bibliometric com-

parisons doesn't have much effect on whether an individual researcher chooses to come to the region or not; an individual researcher looks more at the research group or the subject area in which s/he is interested, Bo Ahrén says.

At the same time, Medicon Valley's international reputation is still of importance for attracting talents, he says.

Stem cell research and neuroscience

The largest research areas in the life sciences at Lund University are neuroscience, diabetes and stem cells, followed by cancer. Other, somewhat smaller – yet, according to the university, competitively relevant areas – are coagulation and cardiology. With Skåne University Hospital, the university is also successful in transplants.

According to the university, stem cell research has long since been an area of excellence, and last year the Wallenberg Centre for Molecular Medicine at Lund University opened. The research centre focuses on regenerative medicine. A partial objective is to unite clinical research and lab research, and all of the positions were filled this year, reports Bo Ahrén.

Other research centres highlighted by the university are the Centre of Excellence in Biological and Medical Mass Spectrometry and Lund Protein Production Platform (LP3).

Some of the larger research areas in the life sciences are animal super senses, the production of biofuel from agricultural waste, molecular biology and structural biology.

DEAN OF RESEARCH AT DTU BELIEVES IN INTERNATIONAL COLLABORATION

While Medicon Valley does rather well in the bibliometric comparison with nine other European life science clusters, more international collaboration could strengthen its position still further, says Katrine Krogh Andersen, Dean of Research at the Technical University of Denmark (DTU). Medtech is becoming an increasingly important research field globally and DTU is bringing its medtech know-how into the limelight with a new department.

– I would say that Medicon Valley is somewhere in the middle. We're not doing poorly, but we aren't at the top, either. It's apparent – as the analysis also shows – that there is a lot of national collaboration in the region, whilst the Cambridge-Oxford-London cluster in this comparison has a lot of international collaborations, says DTU's Dean of Research Katrine Krogh Andersen, commenting on the comparative analysis done by CWTS.

She points out that many of the other clusters include universities with a very strong emphasis on international research, and that it can be difficult for centres of learning in Scandinavia to compete for example with the English-speaking university in the UK that comes in at the top of more or less every ranking list. Katrine Krogh Andersen finds it unfortunate, however, that the number of citations remains at the same level throughout the entire period under scrutiny in the comparison despite the steady increase in the number of publications.

– That might also be related to the analysis showing relatively strong national collaboration in Medicon Valley, whilst Cambridge-Oxford-London for example, which really stands out, has much stronger international collaboration. It's definitely possible that a greater focus on international collaboration could contribute to a greater number of citations, because it's a question of who sees the research, and for whom the research is relevant, she says.

Wanted: Targeted research funds

Medicon Valley needs to focus more on international collaboration, says Katrine Krogh Andersen.

– We've built up a very strong foundation for collaboration in Denmark, but companies need to work internationally, and Medicon Valley as a whole needs to become more visible internationally. Scandinavian collaboration can be strengthened,

working via the various Scandinavian vehicles that are already in place, because there are strong research environments in Sweden and Scandinavia. I believe that could work well; it's also a question of which areas are strong, she says.

Today, Lund University is in the absolute top among the universities that DTU co-publishes with, and in general has extensive collaboration

with. Primarily because of the geographic vicinity, but also because of the research infrastructure being established there, such as the materials research facilities European Spallation Source, ESS, and Max IV. But Katrine Krogh Andersen

believes that trans-Øresund and Nordic collaborations could increase significantly, for example through joint PhD training programmes.

– Working internationally, one often sees that the Scandinavian countries are capable of a lot when combining efforts. We have a great deal of culture in common and similar rules and regulations; that often makes collaboration very simple and straightforward, she says, also pointing out the possibility to seek research funds that specifically target Nordic collaboration.

DTU works actively to secure more EU-funds for its research, says Katrine Krogh Andersen. This also benefits international collaboration in and of itself, as it is one of the purposes of EU-financing. In addition, the university is working to increase the number of international alliances, as well as student exchanges.

A new department for health tech

As a technical university, DTU's focus on the life sciences has traditionally not been particularly strong, but this has been changing over the past decades. Last year, the researchers from DTU Aqua, DTU Food and DTU Vet were brought together in a new complex for the life sciences on DTU's campus in Lyngby. According to Katrine Krogh Andersen, this



Medicon Valley needs to focus more on international collaboration, says Katrine Krogh Andersen.

has already had significant synergetic effects.

– Over a longer period of time the university has experienced a still stronger pull on its specialised technical skills and insight in the medtech field: the pull comes directly from research partners in companies and hospitals, and is seen in research programmes for all the larger public and private funds. It's a global awareness that a solution to future health challenges hinges on technological solutions regarding diagnostics and treatment: personal, efficient and targeted, she says.

This will have another concrete impact on DTU's organisation from 1 January 2019. Nearly 300 researchers, primarily from the existing institutions DTU Nanotech and DTU Electro, will be brought together in the new department DTU Health Technology.

– The same thing is happening in very many places around the world right now – a lot of technical universities are looking to the bio-, life science-, med-tech field; there are a great many technological, physical, and chemical methods that are ready for implementation in much more complex biological systems today. A lot is going to happen in that area in the coming years, says Katrine Krogh Andersen.

One aspect of that is that the materials research facilities ESS and Max IV in Lund are expected to be used relatively extensively for life science research. For DTU, that means for example that expertise in hard materials shifts focus to the study of biological systems as well. She also sees a more economically grounded explanation for DTU's shift toward the life sciences that is related to the private Danish research foundations' focus.

– Relatively speaking, there are a lot of funds for life science research in the Danish system because of our large private foundations, so we also have a greater volume of research in that area; and then, naturally, there is greater focus on health in society in general. There are a lot of interplaying factors.

Making health technology more visible

The new Department for Health Technology is designed to create synergetic effects when researchers from different fields gather together, but also to become a point of contact for external stakeholders such as companies, foundations and hospitals. DTU also wants to make the field of health technology more outwardly visible, she explains.

Not all of DTU's approximately 700 researchers working on some aspect of health technology will be moving in to the new department. Together, they encompass a broad range of research. Some of the most successful areas in the international playing field are cancer research in a broad sense – from immunology to drug delivery – as well as plant science, microbiology and biotechnology, according to an analysis entitled, "Dansk life science under mikroskop" (Danish Life Science under the Lens) that DTU commissioned from Iris Group in 2017.

Katrine Krogh Andersen also points out protein chemistry, bio informatics and pharmacology as strong research topics in the life sciences at DTU. In addition, DTU and the University of Copenhagen run the Danish National Supercomputer for Life Sciences and the data centre Computerome.

DTU also has a strong collaboration in audiology and hearing with the hearing aid manufacturers.

VICE CHANCELLOR OF MALMÖ UNIVERSITY SUGGESTS MEDICON VALLEY JOIN FORCES IN BRUSSELS

Supporting each other's EU investments could strengthen both the Danish and Swedish sides of the Øresund – and not least their collaboration with each other. That's what the Vice Chancellor of Malmö University Kerstin Tham thinks. She also believes that Medicon Valley could benefit from a creating a more distinct profile, for example by formulating a joint strategy for diabetes research.

Medicon Valley's results and placement in CWTS' bibliometric comparison don't make much of an impression on the Vice Chancellor of Malmö University Kerstin Tham. The former college was officially upgraded to university status on the 1st of January this year.

– It's nothing to boast about, but that could be improved with more cooperation, she says.

Because research on diabetes and other metabolic disorders is strong in the region, Kerstin Tham suggests that it could be an area in which to unify; something that could, in extension, increase cooperation across the Strait.

– I think that a concrete way to increase cooperation would be to have a life science strategy, for example for diabetes. Diabetes is a strong area for us in the region; we have Novo Nordisk, and we're also strong in the clinical aspect at the university hospital here in Skåne. And diabetes is a global health challenge, she says.

In addition, from a Swedish perspective, it could be a way to create a distinct profile for the region in contrast with Stockholm-Uppsala, says Kerstin Tham, who was also formerly vice dean at the Karolinska Institute.

A symposium in Brussels

Kerstin Tham also wants to link Danish-Swedish collaboration on a life science strategy to increased cooperation vis-à-vis the EU. She advocates for example joint applications for EU research funding, with universities bringing in or referring to one another. EU funding in particular is one thing in which she finds Danish learning institutions have been very successful, and as she sees it, their Swedish counterparts could climb on board – which

would support researchers in both countries.

Recently, the collaboration agency for southern Sweden's universities and colleges, Lärosäten Syd, recruited an employee who will focus on its special issues in Brussels.

– One way to get started with a strategy in Medicon Valley for e.g. diabetes would be to hold a symposium in Brussels together with the businesses.

I think it's important to start with something concrete. It's difficult for us – as the university leadership – to steer research, but we can for example organise meeting places, like a seminar in Brussels, she says.

Practical obstacles

Like other university representatives, Kerstin Tham also feels that one way to strengthen re-

search cooperation between Denmark and Sweden would be to start up more cooperative educational efforts. From a practical perspective however, it isn't that simple; national regulations throw a spanner in the works when it comes to transferring funds for the costs between the two countries.

– It's significantly easier for us to collaborate with Swedish universities and colleges, since we are part of the same system. At the same time, we have quite a lot of freedom, so we should be able to find ways to facilitate that. And education is also important to remember, since it is the port of entry to research collaboration, she says.

In order for the universities to gain a better overview over and eliminate the obstacles and difficulties that working over national borders entails, Kerstin Tham has called for an analysis of the situation. She also feels that the conditions for collaboration are favourable between two countries with as many similarities as Sweden and Denmark.

– At Lärosäten Syd, part of our agenda is to re-



Kerstin Tham believes that collaborations will increase for Malmö University in particular in the future, when Danish institutions of learning realise that the newly-official Swedish university can be a fully-fledged partner.

se and to locate issues that we can work on with the other centres of learning around the Øresund.

She also believes that collaborations will increase for Malmö University in particular in the future, when Danish institutions of learning realise that the newly-official Swedish university can be a fully-fledged partner.

– The divisions are different on the Danish side than they are in Sweden; not everyone has understood that we've been working as a university in many research areas for a long time, she says.

Worthy business collaboration

One contribution that Malmö University can make to collaborations is that it is accustomed to working with businesses on research, says Kerstin Tham. Business collaboration is namely a common occurrence at Malmö University in particular; this is largely due to the possibilities the institute has to apply for research funds from the Knowledge Foundation in Sweden, she explains. The Knowledge Foundation awards funds to researchers at colleges and young universities on the condition that the research is performed in cooperation with businesses.

Life science research is currently not very comprehensive at Malmö University, but it is set to increase somewhat as the institute receives more

allocated funds for research due to its transition from college to university.

Among other things, a new research programme is being started in dental health to identify risk patients with biological markers present in the saliva at the research centre Biofilms – Research Centre for Biointerfaces. The research centre, which brings together researchers from three departments – Health and Society, Technology and Society, and the Faculty of Odontology – forms a large part of the life science research at Malmö University, and according to the university, some of the environments are internationally successful. These are above all Oral Biofilms at Interfaces, Biobarriers and Pharmaceutical Design, and Smart Materials at Interfaces.

In addition, Malmö University also has one research area that can be categorised in part as life science. It concerns citizen health, that is, how health varies between people in vulnerable and more affluent areas.

– The research is not only epidemiological; its points of departure are the individual, the group, and society, and the research is much more applied. We also look at various types of biodata and health data, including for example diabetes, says Kerstin Tham.

MORE THAN 8 000 UNIVERSITY RESEARCHERS IN THE LIFE SCIENCES – AND ABOUT 6 500 AT OTHER RESEARCH INSTITUTIONS

Universities are an important part of research in the region; apart from the largest ones, there is also the Swedish University of Agricultural Sciences in Alnarp, which enjoys a high position in its field on many ranking lists. However, a large part of the region's research is performed at hospitals and other research institutions, where there are almost as many researchers as there are at the universities.

The University of Copenhagen, Lund University, the Technical University of Denmark and Malmö University have all been presented on the preceding pages, but there is much more life science research in Medicon Valley. CWTS' review of life science research in the region includes all research published in scientific articles from 2006-2016 by universities, regions and other research institutions, as well as a smaller quantity of publications by businesses. Thus, in this report, we also look at research done by regions and at research institutions, as well as research performed at universities. This review, including research initiatives and collaborations presented in this section, is based on our own research and is not a part of CWTS' comparison.

It is important to exercise caution when comparing the number of employees at universities and research institutions on one hand and regions on the other, as researchers for the regions – i.e., at hospitals – usually only dedicate part of their working hours exclusively to research.

UNIVERSITIES

The Swedish University of Agricultural Sciences in Alnarp

Located between Malmö and Lund, SLU Alnarp is one of the Swedish agricultural university's three largest campuses. The university is spread throughout Sweden, and its main campus is in Uppsala. In Alnarp there are 171 researchers in the life sciences, including in chemical ecology, plant breeding, biobased raw materials, and biobased products and applications. The lattermost of these fields studies e.g. the use of plant proteins for biobased products.

Associated with this is also a new plant breeding centre for food crops, SLU Grogrund, which is coordinated by SLU Alnarp. The Swedish government has allocated 90 million SEK to build up the centre

over a three-year period. The goal is for it to become permanent, with continued government funding. The centre aims to produce new crops adapted to a changing Swedish climate.

Another new initiative involving SLU Alnarp, as well as the University of Copenhagen and Lund University, the University of Helsinki and the University of Tromsø, is NordPlant. The research collaboration started on 1 January this year, and it also concerns preparing agriculture and forestry for a changed climate through joint exploitation of infrastructure. NordForsk is funding the collaboration, which will last three to six years.

A smaller research group in chemical ecology at SLU whose international success the university highlights studies how odours can be used to affect vectors of e.g. malaria and dengue fever. It is considered to be in a class with the world's top researchers, and this year it won the so-called Ig Nobel Prize for a study that shows that a wine expert can detect the odour of a single female fruit fly that has landed in a glass of wine.

SLU Alnarp is also highly active in collaborations with the commercial sector in e.g. agriculture, horticulture, food, chemicals, medicine and material.

University of Southern Denmark – The National Institute of Public Health

The National Institute of Public Health was previously a state-owned research institute, but is now part of the University of Southern Denmark, although its physical location is in Copenhagen. The National Institute of Public Health has no students, but contributes to teaching in public health sciences at the University of Southern Denmark in Odense. It employs 106 researchers.

The research performed there concerns public health, but the focus is on e.g. large-scale surveys of the population and the population's health

status. More specifically, it revolves around for example preventive efforts, promotion of health and treatment and public health initiatives, as well as the health and well-being of children and youth, intervention research, smoking, alcohol, physical activity, chronic illness, health inequity, and mental health.

The National Institute of Public Health also conducts large-scale surveys of public health and performs research on the population's health status regarding diseases, mortality, risk factors, disease consequences, health-related quality of life, health behaviour, function level, living conditions and environmental impact.

The Institute has an authority function and provides health authorities with research and counsel on public health.

The National Institute of Public Health moved to new premises in Copenhagen this year.

Roskilde University

Life science comprises a small part of the research performed at Roskilde University. According to figures from 2016, it involves 55 researchers.

The largest research area in the life sciences at Roskilde University is biomedicine, which comprises biomedical research, protein and peptide research, as well as cell biology research. A small research group that performs strong research according to the university studies antifreeze proteins.

Another large research area in the life sciences that the university highlights is green chemistry,

where researchers strive to e.g. make new types of biofuel through the development of new enzyme systems. Other research areas in closely related areas are aquaculture and ecotoxicology.

Roskilde University is a traditional transdisciplinary university that collaborates extensively with businesses as well as hospitals.

Kristianstad University

Technically a college, Kristianstad University's focus is more on education than on research. A total of 50 people work in life science research there.

On the whole, the largest area of research at Kristianstad University is health science, with the research platform "Collaboration for Health", where new research results are implemented in collaboration with Region Skåne and municipalities near Kristianstad.

The institute's life science research also includes Biomedicine, Food and Meal Science – not least in the research environment Food & Meal in Everyday Life (MEAL) – and Environmental Science, focused on e.g. biological, chemical and biomedical research.

Aalborg University in Copenhagen

At Aalborg University's Copenhagen campus, life science research is performed by two research groups with a total of 24 researchers, according to figures from 2017. The groups are active in two widely different areas: The research group Centre for RNA Medicine at the Department of Clinical Medicine performs research on non-coding RNA and RNA medicine in relation to cancer, whilst the Section for Sustainable Biotechnology, which is part of the Department of Chemistry and Bioscience, focuses predominantly on biorefinery. Researchers there study e.g. how microorganisms such as bacteria and fungi can break down biobased raw materials into sugar or produce enzymes.

Other learning institutions

Copenhagen Business School (CBS) does not conduct life science research in the traditional sense, but it is touched upon, for example through research in organisation and public management. CBS also collaborates with the University of Copenhagen and DTU on Business Administration and Bioentrepreneurship training.

The vocational school the Copenhagen School of Design and Technology conducts a small amount of research on optometry.

PHOTO: NEWS ØRESUND



THE REGIONS – HOSPITALS

The Capital Region of Denmark

The Capital Region of Denmark is an important research actor in the region. According to the most recent figures, from the turn of the year 2016-17, there were around 4 000 researchers, in the sense that they dedicated at least ten per cent of their working hours to research. They work at a series of hospitals in the region – the largest group is at Rigshospitalet in Copenhagen – and a smaller number of them are also employed by a university in the region.

According to the region's own bibliometric comparison from 2015, the three largest research areas in the Capital Region of Denmark are Oncology, Cardiac and Cardiovascular Systems, and Endocrinology and Metabolism, i.e. diabetes research. The research areas that place highest in terms of citation frequency however are Medicine, General and Internal, Reproductive Biology and Obstetrics and Gynaecology.

In a new research strategy for the years 2018-2022, the Capital Region of Denmark determined that it will invest in personalised medicine and research on health services – that is, health care as an organisation and in interaction with the population. An additional objective concerns clinical research and prevention and the promotion of health.

Region Skåne

Region Skåne has around 1 800 researchers. Of them, a number of professors also work for a university in the region – usually Lund University.

In Region Skåne and at Skåne University Hospital in Lund and Malmö, the most important research areas, according to the region, are cancer, neurodegenerative disorders, cardiology, stroke, musculoskeletal disorders, transfusion medicine and haematology, genetics, diabetes, nursing care and primary care.

In addition, Skåne University Hospital performs thriving research in childhood oncology, children's surgery, heart and lung transplantation.

As of 2018, Region Skåne is coordinating the collaborative project Genomic Medicine Sweden, which focuses on implementing personalised medicine in Swedish health care. Region Skåne also takes part in a national project – CAMP – to develop advanced cell and gene therapies, among other things.

In an evaluation conducted in 2017 by the Swedish Research Council Skåne was the highest ranking region in Sweden with regard to the clinical

importance and social relevance of the research performed, and the scientific quality and clinical relevance of its research publications were found to be above national averages.

Region Zealand

Region Zealand has approximately 500 researchers. The research areas highlighted by the region are surgery, dermatovenerology, psychiatry, and obstetrics and gynaecology.

This year, two research projects at Zealand University Hospital have been designated by the university hospital as elite research consortia. They concentrate on cancer research, with the overall objective of improving patients' immune systems before and during treatment, as well as on fertility and gestation research, where the focus is on improving fertility treatments and studying the role of the immune system during pregnancy.

RESEARCH INSTITUTIONS

The State Serum Institute

The State Serum Institute, a research institution of the Danish Ministry of Health, employs 130 researchers and is located in Copenhagen. The institution performs research in three primary areas, all of which can be categorised as life science: diagnostics with focus on prevention and treatment; epidemiological monitoring and research; and vaccination research.

The diagnostics area focuses on e.g. infectious and congenital diseases, as well as genetic and immunological diseases. The State Serum Institute also monitors the incidence of infectious diseases and antibiotics resistance in Denmark. Within the area of vaccination research, the institution works to develop new vaccines for TBC, chlamydia, malaria and HIV.

The Danish Cancer Society

The Danish Cancer Society is a patient organisation with a research centre in Copenhagen at which about 250 researchers work. Seven of these are also employed at a university in the region. The organisation's purpose is to fight cancer and its side effects via research, prevention, and patient support. At the Centre for Cancer Research, run by the Danish Cancer Society, research is conducted on e.g. nutrition, genes and environment, viruses, lifestyle and genetics, cell death and metabolism, and stress and survival.

MORE INTERNATIONAL LIFE SCIENCE STUDENTS TO MEDICON VALLEY

The number of international students studying in life science programmes in Medicon Valley went up 3.5% in the academic year 2016/17, compared to 2015/2016. Since 2008, the number of life science students in the region has risen 73%. The number of international talents included in the Danish and Swedish governments' national tax relief schemes is also rising.

In total, 3 483 international students were enrolled in life science programmes in Medicon Valley in the academic year 2016/17. That is a 3.5% increase compared with the previous academic year. Of the total number, 1 215 were PhD students, which is 1% more than in the previous academic year, masking over that there were 4% more international students on the Danish side of the Øresund and 7% fewer in Skåne. In total, 1 101 of the 3 483 international students in Medicon Valley – including exchange students, foreign PhD students and free mover students who organise their studies in the country of their own accord – were conducting their studies in Skåne.

The number of international life science students in the Medicon Valley area has increased 73% since 2008, primarily due to an increase in the number of international life science students in the Capital Region of Denmark.

In Denmark however, health care training programmes have a lower proportion of students from abroad than e.g. technology or social science



training programmes, according to a new report from Denmark's Ministry of Higher Education and Science. The report also shows that only half of international students are still in Denmark five years after commencing their studies. On the basis of the

NUMBER OF INTERNATIONAL STUDENTS IN THE STUDY YEAR 2016/17

	Number of students	of whom in research programmes	Change 2008/09 - 2016/17
Skåne	1 101	309	20%
Stockholm-Uppsala region	3 883	1 560	34%
Västra Götaland	841	231	8%
Sweden, rest of	1 892	304	26%
Sweden	7 717	2 404	27%
Eastern Denmark	2 382	906	118%
Denmark, rest of	1 477	321	55%
Denmark	3 859	1 227	88%
Medicon Valley	3 483	1 215	73%

Source: Statistics Sweden and Statistics Denmark

report, the Danish government wants to reduce the number of foreign students admitted by about one thousand, as well as evaluate whether the new training programmes in English are relevant for Danish society. The proposal has been met with criticism by universities and labour unions, however.

For several years now, both Denmark and Sweden have been offering special tax schemes for foreign employees to make it easier for companies and universities to attract talent from other countries. The Danish system is distinctly more advantageous. While a key employee in the Danish scheme needs to earn a minimum of 65 100 DKK per month including employee benefits, a foreign expert in Sweden needs a monthly salary of 91 001 SEK to be approved. When comparing the minimum level for the salary in Denmark and Sweden, it is important to note that the salary on a Swedish payslip is generally lower than its Danish counterpart due to differences in the way the social security systems are financed. In

Sweden, employers have to pay employer contributions for the employee in addition to their salary, whilst in Denmark, the social security system is financed via income taxes. In Sweden, tax relief can be received for a period of maximum three years; in Denmark, the tax relief period was extended from five to seven years in 2018.

In 2016, the Danish tax scheme was used by 6 397 highly qualified employees from other countries; of these, 2 645 were researchers, according to statistics from the Danish Ministry of Taxation. In 2017, 975 applications were made to the commission that deals with the tax relief scheme in Sweden, Forskar-skattenämnden; of these, 740 were approved.

When it comes to recruiting international talents, there are high hopes for the globally leading neutron research facility European Spallation Source, ESS, in Lund, which will open for research in 2023, as well as for the synchrotron radiation facility MAX IV, also in Lund.



PHOTO: NEWS ØRESUND

OTHER RANKINGS: THE UNIVERSITY OF COPENHAGEN PLACES BEST IN MEDICON VALLEY

The University of Copenhagen placed between 29th and 109th on the most prestigious ranking lists for the world's universities: QS World University Rankings, Times Higher Education Ranking and Shanghai Ranking. With one exception, it is the highest ranking institute in Medicon Valley, followed by Lund University and then DTU. Leiden Ranking, which is based entirely on the number of publications and citations, shows somewhat different results.

There are many actors who rank the universities of the world according to various parameters. In this report, we choose to focus on those that are generally considered most reliable. The results can differ considerably, as the parameters used to compare the universities can vary significantly between ranking lists, as can the weight given to each and every one of those parameters.

This year, for example, the University of Copenhagen has its best placement, 29, on the Shanghai Ranking 2018, which differs e.g. in that articles published in the journals Nature and Science are weighted heavily, as is the proportion of researchers who have won a Nobel Prize. The ranking list is prepared by an independent organisation, but was started by Shanghai Jiao Tong University in 2003.

The institution's placement on QS World Rankings 2019 list is quite a bit lower: 79. QS World Rankings is based half on their calculations of the university's reputation and half on fact; here, the proportion of students per department is of comparatively great importance. The ranking is prepared by the British student advisory company Quacquarelli Symonds.

On two of the three renowned ranking lists, the University of Copenhagen placed highest out of the universities in Medicon Valley. On Times Higher Education Ranking 2018 however, Lund University attained a higher position – 93rd – than the University of Copenhagen at 109th. Times Higher Education Ranking, which is published by the eponymous journal, places relatively substantial import on teaching as well as somewhat more importance on citations than the others.

Lund University otherwise usually ranks somewhat lower on the lists than the University of Copenhagen, even in subject-specific rankings, but the learning institutions' results do not adhere to this. On the Shanghai Ranking, where the University of Copenhagen attained its best position yet, Lund University received its worst, landing between 101-150. Instead, Lund University's highest position, 92, is on QS World Rankings.

Consistently at third place in the region is the Technical University of Denmark (DTU), which places between 112 and 200 on the lists. DTU's results are also highest in QS World Rankings and lowest in Shanghai Ranking (151-200).

Ranks higher – and lower – than last year

There are subject-specific variations for a number of ranking lists, although they are not updated as frequently. Since last year, QS World University Rankings has produced a new ranking for Life Sciences & Medicine on which the University of Copenhagen places 25th, followed by Lund University at 79th. Compared with the two most recent years, the University of Copenhagen's position has been more or less the same, whilst Lund University has advanced slightly.

As far as the overall ranking lists are concerned, it is not possible to identify any clear tendency, other than the region's learning institutions shifting up and down slightly compared to last year. The nature of the change depends in part on each university's results, but also on the performance of the others. The three universities at the top from Medicon Valley are ranked somewhat higher in this year's edition of the Times Higher Education Ranking, but lower in QS World University Rankings. There have been no notable changes in the Shanghai Ranking.

The other universities located entirely in the region are only included occasionally on the ranking lists: Roskilde University is ranked between 401-500 in the Times Higher Education Ranking, and Malmö University came in 387th on the subject-specific ranking done by QS for the subject Life Sciences & Medicine.

In addition to those, three universities with campuses in the life sciences in the region – Aalborg University, the University of Southern Denmark, and the Swedish University of Agricultural Sciences – feature on all of the four ranking lists selected, in various orders. There is no information regarding if or how research in Medicon Valley impacts these placements, however.

SCIENCE PARKS IN MEDICON VALLEY: Expansions and reorganisations



PHOTO: DTU SCIENCE PARK

There are around 1 500 companies with a total of approximately 17 000 employees at the science parks in Medicon Valley whose focus is fully or partly on the life sciences. Those science parks are: COBIS, DTU Science Park, Ideon, Medicon and Medicon Village, and the start-up ecosystem Symbion and the food- and health-oriented science park Krinova are also included.

- Some of the science parks in Medicon Valley emerged in times of crises – for example Ideon, which was founded in Lund during the economic slump of the 1980s, and Medicon Village, which was founded as a result of Astra-Zeneca leaving Lund in 2011.
- Founded in 1983, Ideon was Skåne's first science park; Symbion on the Danish side of the Strait was established in 1986. The newcomer to the group is Medicon Village in Lund, which was founded in 2012.
- The science parks often set out from the same point of departure: to create a better connection and collaboration between research and business innovation.
- Many of the science parks profiled in this report have plans to expand and effectuate changes to their internal structures. Among other things, DTU Science Park changed its name from Scion DTU and is scaling up with a new incubator; Medicon Village has split its operations into two companies, separating the science park's innovation and real estate activities.
- A total of nine incubators/accelerators at the science parks are included in this report.
- Many of the science parks in the region with operations in or focus on the life sciences are scaling up. Of them, Medicon Village, Medicon and DTU Science Park are currently constructing new buildings, and COBIS' facilities are now fully leased.

GREATER COPENHAGEN'S SCIENCE PARKS – FROM A CRISIS IN SKÅNE TO A MAJOR INVEST- MENT BY THE NOVO NORDISK FOUNDATION

Science parks are a relatively new phenomenon in the region around the Øresund. The region's first science park, Ideon, was inaugurated in Lund on the 29th of September 1983; the collaboration between academia and business was an attempt to pull Skåne out of a deep recession. More recent additions – Copenhagen Bio Science Park, COBIS, in Copenhagen, and Medicon Village in Lund – follow a new trend where science parks focus on the life sciences. Giving rise to the region's science parks are initiatives from e.g. ministries, universities, foundations or trusts that have donated funds.

The development of science parks in Greater Copenhagen is a reflection of how the innovation system has grown and developed over the years. It has progressed from investments made in a period of deep economic crisis to science parks specialised in the life sciences and increasingly elaborate support schemes such as accelerators and incubators. The most recent addition in the region is the Novo Nordisk Foundation's 392 million DKK investment over the next three years to build up the BioInnova-

tion Institute, BII, at COBIS in Copenhagen. BII brings the innovation system to the next level. It has its own facilities complete with labs in an open and modern environment, as well as funding potential of its own and a structured innovation process that accompanies innovators from the discovery phase to an accelerator and an incubator – all at a high pace. Inspiration for the design of the BII was drawn from a comprehensive study of the world's top innovation environments.

But it all started much more simply than that, in wooden barracks on a field on the edge of Lund during Skåne's deep economic slump in the early 1980s. Skåne had lost significant parts of its ship-building and textile industries and was in dire need of new enterprises and new jobs. Lund University, the Municipality of Lund, the head of government and a colourful aristocrat with a flair for technology who had married into the Swedish industrial Wallenberg family stood for the idea and execution. On the 29th of September 1983, Ideon inaugurated the first of its barracks with a lease contract with the Swedish Ericsson corporation, which had decided to make Lund its base for the development of its mobile phones; today, this is Sony Mobile. The first permanent structure was completed three years later, financed and owned by Ingvar Kamprad and IKEA. Until 2013, the Kamprad family's corporation Icano owned half of Ideon's buildings. They built the high-rise Ideon Gateway before selling their Ideon real estate and leaving Lund.

Initiatives were also taken on the other side of the Øresund Strait in the 1980s to unite university research and businesses in order to generate new and innovative products and companies. In Copenhagen, the science and research park Symbion was formed in 1986.

Today, activities at the two environments differ in many ways from when they were starting out. There are also more science parks in the region, and incubators and accelerators have been established to provide new innovators with concrete assistance on their journey from research to enterprise.

New motivations for science parks

The science parks with a life science focus in the region can be seen as a progression and specialisation of the innovation system with the assistance of various actors – everything from privately donated funds to government decisions. Their starting point is often the same, however: to create a better connection and collaboration between research and business innovation. Business structures have also changed. The small and innovative companies at the region's science parks today are important complements to big companies' research departments. There is a new trend where large companies are offered help with radical innovation through their collaboration with science parks.

The youngest of the science parks highlighted in this report was established in 2012: Medicon Village in Lund. The science park focuses entirely on the life

sciences, and was founded with a donation by the Mats Paulsson Foundation for Research, Innovation and Societal Development and an agreement made with AstraZeneca to take over its research facilities in Lund after its closure. Just like when Ideon was established, it was founded in reaction to a crisis.

In 2009, the Copenhagen Bio Science Park, COBIS in Copenhagen, was established as the result of a political vision created by the Ministry of Higher Education and Science and the Capital Region of Denmark. COBIS focuses on the life sciences and is owned by Symbion Science Park and DTU Science Park.

DTU Science Park was founded in 2004 when the foundation behind the former research centre Forskningscentret in Hørsholm was dissolved, and a joint-stock company was created and given to the Technical University of Denmark, DTU. The science park is located in Lyngby and Hørsholm.

In 1999, the science park Krinova was established in Kristianstad by Kristianstad University, the Municipality of Kristianstad, and the Teknikbrostiftelse in Lund.

Medeon in Malmö was founded in 1985. It was initially called Ideon-Malmö, but became administratively independent from Ideon in 1998. Medeon became the first of the region's science parks to focus on the life sciences.

Symbion in Copenhagen was founded in 1986. Initially, a fund board approved the companies that would be granted space at the research environment. The board consisted of company leaders, professors and deans. Today, Symbion considers itself a start-up ecosystem and an office community.

One of the oldest existing science parks – Ideon in Lund – was founded in 1983. Today, it is one of Sweden's largest science parks.

Current organisation and focus

Many of the regions' science parks have made changes to their organisational structure in recent years. Earlier this year, DTU Science Park changed its name; it was formerly known as Scion DTU. There are two reasons behind the change, says CEO Steen Donner. In part, it was because they wanted a name that tells what they are, and in part because they felt that their name was too difficult to pronounce and few understood what it meant. DTU Science Park also opened the doors to its new incubator workspace in the beginning of 2018. It's called Futurebox, and it can accommodate 30–40 companies at a time.

– We were lacking something between an accelerator and a science park – a place where companies can continue to develop. We are very demanding; they have to earn their keep there. The tangible aspect – where we spur the companies on, endorse them and give them exposure – is not something we have resources to give all 260 of the companies in the science park, says Steen Donner.

COBIS signed a contract with a prominent new tenant at the end of last year: the Novo Nordisk Foundation's major investment the BioInnovation Institute, which is leasing an entire floor. After that, the Japanese pharmaceutical giant Daiichi Sankyo decided to locate its new Nordic headquarters at COBIS. The establishment of the data centre for the Lund-based research facility European Spallation Source, DMSC, in May of 2016 was also important for COBIS' development. COBIS has also broadened its scope to include other fields and seen a great influx of new, small biotech and e-health companies.

For Medicon Village in Lund, 2018 has brought organisational changes. The science park's operations have been divided in two companies, meaning that its real estate and innovation activities will be separate in the future. On top of that, the Municipality of Lund, Region Skåne, Lund University and the foundation that owns Medicon Village have decided to contribute seven million SEK in funds annually. Medicon Village is the newest in a series of science parks in Greater Copenhagen that are focused entirely on the life sciences. The term life science is interpreted broadly and also includes service providers that can support the companies with for example business development, economy and administration.

– Our strategy is for there to be members in the science park with the right competences to help the start-ups develop. We work actively to bring in organisations like those in order to create a community, says Kerstin Jakobsson, CEO of Medicon Village Innovation AB.

At the end of 2016, an announcement was made that the marketing company Ideon AB would be run by Wihlborgs and the real estate companies Castellum and Vasakronan, which own the adjacent property. That meant a geographic expansion for Ideon. Ideon also comprises the companies Ideon Open and Ideon Innovation.

Today, the City of Malmö owns 60% of Medeon, and the other 40% is owned by the real estate company Wihlborgs. About five years ago, Medeon started an incubator that could accommodate about

INCUBATORS AND ACCELERATORS AT THE SCIENCE PARKS

- **IDEON OPEN/BEYOND**
– a collaborative business accelerator run by Ideon Open
- **THE BIOINNOVATION INSTITUTE**
– discovery, accelerator and incubator with financial support located at COBIS
- **DANISH TECH CHALLENGE**
– accelerator at DTU Science Park
- **FUTUREBOX**
– incubator at DTU Science Park
- **HEALTH2B**
– accelerator at SmiLe in Lund
- **IDEON INNOVATION**
– runs incubator activities at Ideon
- **KRINOVA INCUBATOR**
– incubator activities are an integrated part of the science park Krinova
- **MEDEON**
– an incubator that shares a name with the science park
- **SMILE**
– life science-incubator at Medicon Village in Lund

30 companies. Medeon is one of three science parks featured in the report that focuses entirely on the life sciences.

Symbion includes the life sciences as one of its several prioritised areas. It has three locations in Copenhagen: its main facilities in Østerbro; at Creators Floor at the Copenhagen Business School, and at Univate, which is at the University of Copenhagen, where it replaced the former Orbit on Amagerfælledvej. Together with DTU Science Park, Symbion also owns the science park COBIS.

In the so-called ToY project, the science park Krinova in Kristianstad is working to bring together its focus on food-environment-health with pharmaceutical research to create new and innovative solutions for the health care sector. The project is a collaboration with the incubators SmiLe in Lund, Medeon in Malmö and GU Ventures in Gothenburg. Today, Krinova sees itself more as an innovation arena than as a science park.

FIVE

science parks in Medicon Valley that completely or significantly focus on the life sciences are profiled in this report: COBIS, DTU Science Park, Ideon, Medeon and Medicon Village. Also included are the start-up ecosystem Symbion and the food- and health-oriented science park Krinova, which focus partially on the life sciences.

Structural changes

Many of the science parks in this report are making changes to their internal structures. Among other things, Scion DTU changed its name to DTU Science Park; Medicon Village's activities have been split into an innovation and a real estate company, and COBIS has expanded its focal area from strict biotech and opted for a broader perspective on healthcare.

PHOTO: NEWS ØRESUND



Medicon Valley's science parks are contributing new listed companies

More Swedish life science companies are listed than Danish. What's more, many of the Danish companies that go for an IPO choose to do it in Stockholm. The explanations include differences in the two countries in how stock is taxed, as well as different traditions of saving in stocks.



PHOTO: NEWS ØRESUND

Medicon Valley's major new initiative is called the BioInnovation Institute, BII. The initiative is being funded by the Novo Nordisk Foundation, and the budget is 392 million DKK. BII started up earlier this year at the science park COBIS in Copenhagen. The aim is for life science research at the region's universities to generate more new companies.

1 500

There are around 1 500 companies with a total of approximately 17 000 employees in the science parks in Medicon Valley that are fully or partially focused on the life sciences.

Many of the science parks are expanding; among others, this is true for Medicon Village, which is building a new office complex that will accommodate 600 people; Medeon, which is commencing construction on a building with 200 workspaces; and DTU Science Park, which is scaling up with a new incubator – Futurebox – as well an additional 20 000 m² in Lyngby.

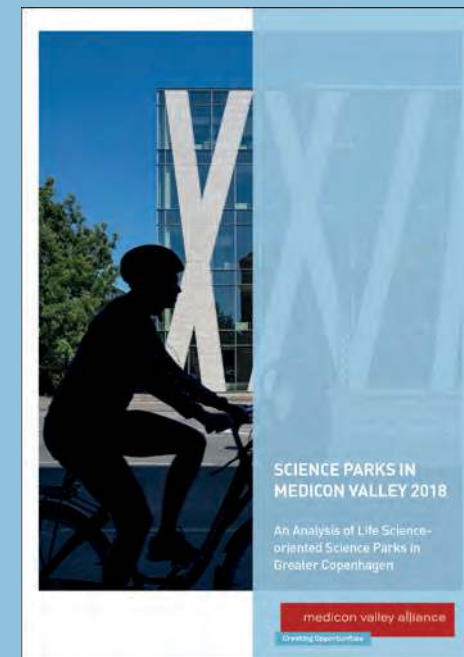
35

companies active in the pharmaceutical sector were listed on Nasdaq Nordic last year. This autumn, Spotlight Stock Market (formerly Aktietorget) will be opening a marketplace in Copenhagen.

Science Parks in Medicon Valley

Read more in MVA and Øresundsinstituttets interim report from 2018

The topics in this chapter are discussed in greater detail in the progress report "Science Parks in Medicon Valley 2018", published in June 2018, and like this report, prepared by Øresundsinstituttet for Medicon Valley Alliance. The report contains interviews with representatives from all of the science parks in the region with a partial or complete focus on the life sciences, as well as an overview of other innovation environments.



The science parks and incubators in Medicon Valley have company: co-working spaces are on the rise, and many are private initiatives

The grassroots initiative Copenhagen for the Win and its hashtag #CPHFTW have become well known as a collective symbol for the startup community in Copenhagen with one eye trained on the other side of the Øresund Strait.

The Creators Community, which consists of Matrikel1, Founders House

and Startup Village in Copenhagen, is an important player in the field. The newest addition is Rainmaking at the farthest end of Copenhagen's Langelinie. Rainmaking runs several shared working spaces in Copenhagen. Accelerace, characterised by Vækstfonden as a world leading seed accelerator, is an important actor in the Danish innovation system.

On the other side of the Øresund Strait in Malmö is the municipal incubator Minc.

The Startup House of Malmö and the community Media Evolution is an associate of the meeting place and co-working space Media Evolution City. Mindpark is a creative co-working space in central Helsingborg with plans to set up a location in Hyllie in Malmö. It is owned by the private company Collaboration Concept AB.

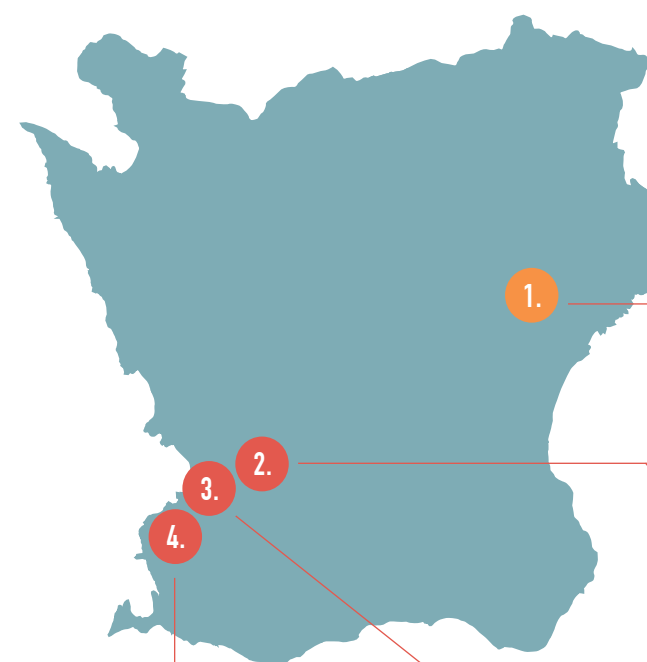
PHOTO: NEWS ØRESUND



SCIENCE PARKS IN GREATER COPENHAGEN

**1. DTU SCIENCE PARK****Number of companies:** 260**Number of people:** 3 400**Founded:** 2004 (when the former research centre in Hørsholm was linked to the university and the foundation that owned it was dissolved)**Location:** Lyngby and Hørsholm**Focus:** Deep tech. Life science, biotech and medtech comprise around 40% of the science park**Incubator:** Futurebox**Accelerator:** Danish Tech Challenge**Miscellaneous:** With Symbion, DTU Science Park owns Copenhagen Bio Science Park, COBIS, in Copenhagen. Earlier this year, DTU Science Park changed its name from Scion DTU**2. SYMBION****Number of companies:** around 450**Number of people:** ca 2 000**Founded:** 1986**Location:** Copenhagen (main facility in Østerbro, Creators Floor at CBS, and Univate at the University of Copenhagen)**Focus:** Life science, foodtech, edtech, hardware/makerspace and SaaS (Software as a Service) at the main facility**Incubator:** -**Accelerator:** -**Miscellaneous:** With DTU Science Park, Symbion owns Copenhagen Bio Science Park, COBIS, in Copenhagen

- Science park with complete or predominant focus on the life sciences
- Science park or environment with partial focus on the life sciences

**3. COBIS****Number of companies:** around 100**Number of people:** around 400**Founded:** 2009**Location:** Copenhagen**Focus:** Life Science**Accelerator/Incubator:** Biolnnovation Institute**Miscellaneous:** European Spallation Source Data Management & Software Centre, DMSC, has based its activities at COBIS**1. KRINOVA****Number of companies:** 118**Number of people:** 300**Founded:** 1999**Location:** Kristianstad**Focus:** Food, the environment, and health**Incubator:** Krinova**Accelerator:** Krinova**Miscellaneous:** Owned by the Municipality of Kristianstad and Kristianstad University's holding company**4. MEDEON****Number of companies:** 60**Number of people:** 450**Founded:** 1985**Location:** Malmö**Focus:** Life science**Incubator:** Medeon**Accelerator:** -**Miscellaneous:** -**3. IDEON****Number of companies:** 400**Number of people:** 9 000**Founded:** 1983**Location:** Lund**Focus:** Has a broad profile with four focus areas: future transportations, smart cities, smart materials and health tech.**Incubator:** Ideon Innovation**Accelerator:** Ideon Open/Beyond**Miscellaneous:** The brand Ideon is owned by SUN, a foundation for collaboration between academia and business, and is run by the Skåne County Administrative Board, Lund University, and the Chamber of Commerce and Industry of Southern Sweden**2. MEDICON VILLAGE****Number of companies:** 120**Number of people:** 1 600**Founded:** 2012**Location:** Lund**Focus:** Life science**Incubator:** SmiLe**Accelerator:** Health2B**Miscellaneous:** Owned by the Mats Paulsson Foundation for Research, Innovation and Societal Development and located in AstraZeneca's former R&D facility, which it vacated in 2011

Source: Based on information provided by the science parks in the interim report "Science Parks in Medicon Valley 2018" which was first published in June 2018.

THE SCIENCE PARKS' EXPANSION PLANS

Many of the science parks in the region with operations in or focus on the life sciences are scaling up. In Lund, Medicon Village is building a new office complex that will accommodate 600 people, while in Malmö, Medeon is commencing work on a new building with 200 workplaces. This spring, DTU Science Park inaugurated the new incubator Futurebox, the facilities for which are made up of refurbished containers. The science park DTU's extension also includes an additional 20 000 m² in Lyngby. COBIS' facilities in Copenhagen are now fully leased, and discussions are currently being held with the city about future extensions. Ideon made geographical changes in 2016 when it expanded its owner structure so that three real estate companies are now behind Ideon AB – Wihlborgs, Castellum and Vasakronan.

In May, DTU Science Park inaugurated its new incubator, Futurebox, in Lyngby. The incubator can accommodate 30–40 companies at a time, and the building consists of refurbished containers. On top of that, construction at DTU Science Park is also underway in Lyngby and Hørsholm. According to CEO Steen Donner, they'll need to grow even more.

– We are constructing another 20 000 m² in Lyngby and another building in Hørsholm for a client. We can – and will – definitely grow larger. From a strategic perspective we're not quite where we should be today; we're too big to be small and too small to be big, he says.

Medicon Village's new office building with room for 600 people is being built in Lund and should be complete next summer. Today, there are around 1 600 people working in Medicon Village, which is located in the R&D facility that AstraZeneca vacated in 2011.

– We can now offer space in a new office complex to both smaller and larger companies. Our aim is to be a science park that is available for companies all of the time, where they can grow from idea to start-up, scale-up, growth company to international enterprise. We're reaching capacity as far as office space is concerned, and we have very few labs left. That's why we're building now and can continue building more, says Kerstin Jakobsson, CEO of Medicon Village Innovation AB.

There are other plans for the area that will allow additional office buildings, residential spaces, a hotel and a parking facility.

Ideon started out in barracks on a field in Lund in the 1980s. Until 2013, the Kamprad family owned half of the buildings constructed as the science park grew with its corporation Ikano. Before selling, Ikano built the high-rise Ideon Gateway. Today, the real estate company Wihlborgs owns the original Ideon site. In 2016, Ideon's geographical area and owner structure were both expanded through the marketing company Ideon AB to also comprise the nearby real estate owned



DTU Science Park's new incubator Futurebox is made of refurbished containers.

by Castellum and Vasakronan. During the planning phase, there has been talk of densifying the relatively scattered Ideon area, as well as of connecting it to the tram that will pass by Ideon on the way to ESS.

In Malmö, Medeon is scaling up its science park with a new structure that will accommodate 200 workplaces. The approximately 100 million SEK investment is being made by Wihlborgs, which owns and leases real estate on the site. Companies are waiting in line to get into the science park, says Medeon's CEO Ulf G Andersson.

– For several years now, we have had an occupancy rate of between 95 and 99 per cent. We have also received many enquiries. Around half a year ago, we had 14 companies on a waiting list, many of which were Danish, he says.

Construction will start in May of this year, and the building should be complete and ready for occupancy in the third quarter of 2019, a few months shy of Medeon's 35th birthday. The new building will mean an additional 3 000 m² of leasable space. Today, Medeon comprises 20 000 m².

– We are already in discussions with our tenants, and we are prioritising accommodation of existing Medeon-companies' expansion plans so that they can stay here. As of now, it looks as if the new H-house will fill up very quickly, says Ulf G Andersson.

THE BIOINNOVATION INSTITUTE: OPERATIONS HAVE BEGUN – THE FIRST START-UPS ARE IN PLACE

The Novo Nordisk Foundation's major investment in the creation of a world-class innovation environment is now fully underway. In early September, eight selected start-ups were welcomed for the trial run of the new BioInnovation Institute's Business Acceleration Academy programme, arranged on COBIS' premises in Copenhagen. The Institute's first board has also been appointed, with Dane Sten Scheibye as chairman and Swede Bo Ahrén as vice chairman. Both previously sat on the board of the Novo Nordisk Foundation.

– Why isn't research in Denmark generating more new companies? Why aren't more researchers interested in becoming entrepreneurs, so that society can make better use of their work?

The director of the BioInnovation Institute Thomas Nagy is forthright with the questions that formed the base for the Novo Nordisk Foundation's decision to invest 392 million DKK in a three-year initial phase in order to build up operations at the Institute, with a ten-year perspective. The aim is to get the quality research being done at universities to develop into the life science companies of the future. The project will be evaluated after three years, and if the work being done there fulfils expectations, the BioInnovation Institute will be reorganised as an independent foundation.

In the first half of 2018, the concept for the BioInnovation Institute, BII, was polished, and the premises at Copenhagen Bio Science Park, COBIS, were adapted for the new operations. BII's board members were appointed in late August. The chairperson is the

former chairman of the Novo Nordisk Foundation Sten Scheibye, and the vice chairperson is Bo Ahrén, who is also Pro Vice-Chancellor and professor at Lund University and a former member of the board of the Novo Nordisk Foundation. In September, BII visited Denmark's universities in Copenhagen, Lyngby, Aalborg, Aarhus and Odense to spread information about the new undertaking. The names were also announced of the eight start-ups that will take part in the ten-week initial trial run of the Business Acceleration Academy programme.

The plans to reorganise BII into an independent foundation are also a way of emphasising that the institution is not only for the Novo Nordisk Foundation's network, but for all of society.

– We want to utilise existing networks, and naturally that includes that of the Novo Nordisk Foundation. But we are a national institution with international ambitions, and our projects will reflect that. In that context, it is perfectly natural for us to look toward southern Sweden, says Thomas Nagy.

NEW INNOVATION ENVIRONMENT IN FOUR PHASES

Started in 2018. The Novo Nordisk Foundation has made a grant of 392 million DKK over a three-year period to build up a world-class Danish innovation environment, the BioInnovation Institute. BII will be evaluated after three years. If found up to par, it will be reorganised as an independent foundation.

BII is leasing a floor at Copenhagen Bio Science Park, COBIS. The organisation has 11 employees. The facilities accommodate 160 people, and selected researchers and entrepreneurs receive access to shared office space and laboratories, as well as the meeting place The Square. They are also offered initial funding through a convertible loan, usually in the amount of 10 million DKK. The innovation process is rapid and structured clearly:

The discovery phase – talented researchers and entrepreneurs are invited to develop their ideas at BII.

The transition phase – promising projects are tested and developed, and the entrepreneurs receive training in a three-month accelerator phase. Two batches of 15 participants each go through the accelerator each year.

The incubation phase – when a project has been developed further and established a start-up company, it moves in to the incubator, where it has access to laboratories, advice and networks for 18–24 months.

The growth phase – when companies have brought in external capital, they can remain at BII at market rent.

ANALYSIS: Scientific publications in a European perspective

PHOTO: LEO PHARMA

When the number of scientific publications is examined comparatively from a European perspective, Medicon Valley's universities and research institutions come in sixth out of the ten leading European life science clusters. Their direction of travel is up; in recent years, the region has surpassed Stockholm-Uppsala and Scotland and drawn closer to Munich.

- Several of the university representatives interviewed in this analysis mention that the region needs to assert itself in order to attract researchers, and above all invest in young talent. Another suggestion to increase Medicon Valley's competitive strength is to improve the transborder cooperation between the region's universities.
- Medicon Valley's position in CWTS at Leiden University's comparison is in the middle of the other European clusters surveyed. The analysis shows that during the entire period of 2006 to 2016, 32 027 scientific publications were produced in the life sciences by researchers at universities, research institutions and businesses in Medicon Valley, and that 13% of these are among the ten per cent most frequently cited in the world for their respective fields.
- The life science sector is currently in a new development phase. Pricing pressure in the USA, technological changes toward biopharmaceuticals and gene therapy, digitalisation with artificial intelligence and big data that gives patients greater knowledge about and influence over their treatments are just some of the greater trends affecting the life science sector worldwide.
- The governments of both countries have come to the same conclusion however: the sector is important for growth and employment in the future; for that reason, both governments have put life science firmly on the agenda, with for example newly formed public offices for the life sciences. In industry news, the Novo Nordisk Foundation is making a major investment in a new start-up environment in Copenhagen: the BioInnovation Institute.

MEDICON VALLEY AMONG EUROPE'S TOP LIFE SCIENCE CLUSTERS

The universities in Medicon Valley need to improve transnational cooperation and attract more young research talent to the region: those are some of the suggestions made by representatives of the region's universities to both safeguard and strengthen Medicon Valley's position as one of Europe's ten largest life science research clusters. Over the past ten years, the number of scientific publications produced by researchers in Medicon Valley has risen 23%, which is a greater increase than any of the other clusters. With 32 027 publications in the last ten years, Medicon Valley comes in sixth out of the ten clusters on the top-ten list.

As a sector, life science is based on research advances associated with universities. This edition of the report State of Medicon Valley is thus focused the advances of research in a European perspective. The comparative analysis that Medicon Valley Alliance enlisted the research institute CWTS at Leiden University to perform is unique in that it sets ten leading life science clusters side by side in terms of

their publications and the citation frequency of these in the period 2006-2016/17. Because the analysis shows the cluster in its entirety rather than individual universities, it is possible to perform comparisons in a broader perspective, and it offers answers to questions about the region's research positions in relation to one another that are otherwise open for speculation and the assertions of each region.

The analysis does not consider the amount of resources available to each individual cluster; the report measures only the weight of the respective clusters. Life science businesses do not take the resources and conditions of each research cluster into account, but focus instead on the concrete results that universities and research institutions in the respective clusters are capable of creating in competition with one another.

Sixth place out of ten European clusters

Medicon Valley's place in CWTS' comparison is in the middle of the other European clusters surveyed. The analysis shows that during the entire period of 2006 to 2016, 32 027 scientific publications were produced in the life sciences by researchers at universities, research institutions and businesses in Medicon Valley, and that 13% of these are among the ten per cent most frequently cited in the world for their respective fields.

That brings Medicon Valley in sixth out of ten, both in terms of the number of publications and how often they are cited. This hardly comes as a surprise to representatives for some of the region's largest universities, who are neither impressed nor disappointed.

– It's nothing to boast about, says Vice Chancellor of Malmö University Kerstin Tham, but she also believes that the result could be improved if the region's universities were better at transborder cooperation.

In its report Benchmark Life Science Regions Research for Medicon Valley Alliance 2006–2016/17, CWTS writes that “the benchmark field in this representation is a rather strong one”. In other words, in this particular comparison, sixth place is not bad at all.

Unsurprisingly, the greatest number of publications – 116 263 – were produced by researchers in the life science cluster around London-Cambridge-Oxford in the period studied, 2006–2016. This is followed by the Netherlands, whilst the remaining eight clusters – BioValley, Flanders, Île de France, Medicon Valley, Munich, Scotland, Stockholm-Uppsala and Zurich – come in a bit lower and are rather close in terms of their publication volume.

Medicon Valley: greatest percentual increase

In the period scrutinised, the number of publications by Medicon Valley researchers increased 23%;

this is more than other clusters. In absolute figures, the number of publications by researchers in Medicon Valley rose from 10 465 from 2006–2009 to 12 902 from 2013–2016.

During the studied period, Medicon Valley surpassed both Stockholm-Uppsala and Scotland and approached Munich in terms of the number of scientific publications in the life sciences without sacrificing quality; this can be interpreted as a sign of strength. The increase is also interesting in light of the fact that few of the other clusters in the comparison have had a notable increase in publication volume. There has been an increase in the citation frequency of other clusters' publications

however, whilst Medicon Valley has remained at the same level. In addition, the distance from the top clusters in London-Cambridge-Oxford and the Netherlands is, perhaps unsurprisingly, a large one.

The situation is difficult to change in the short-term, and Medicon Valley needs to try and assert itself in other ways.

Several of the university representatives interviewed mention attracting researchers to the region, and above all investing in young talent, offering good career opportunities in the region. Others propose emphasising the good living conditions in Medicon Valley.

Clear niche strategies in the industry in Medicon Valley have contributed to the successes of the past decade.

Novo Nordisk is a globally-leading company with focus on diabetes care; Lundbeck is an important pharmaceutical company focused on improving the quality of life for people living with psychiatric and neurological disorders. LEO Pharma is making major efforts to become the global leader in dermatology.

But statistics in this analysis show that life science growth has slowed down in Denmark and is just beginning to take off again in Sweden after many years of setbacks.

A sector in transformation

The life science sector is currently in a new development phase. Pricing pressure in the USA, technological changes toward biopharmaceuticals and gene therapy, digitalisation with artificial intelligence and big data that gives patients greater knowledge about and influence over their treatments are just some

PHOTO: NOVO NORDISK



Lars Fruergaard Jørgensen was appointed the new CEO of Novo Nordisk in the autumn of 2016, and Deborah Dunsire was named the new President and CEO of Lundbeck in September 2018.

of the greater trends affecting the life science sector worldwide. Personalised medicine is another growing phenomenon changing the conditions for patients and healthcare, as well as the pharmaceutical companies' business models. That means that companies can no longer live off of their earlier successes.

– Technological changes happen at such an astounding pace. In the 1990s and 2000s there was a dip in pharmaceutical research, but now we've entered a new era with groundbreaking discoveries, not least in cancer treatment, says Ferring Pharmaceutical's chairman and owner Frederik Paulsen in an interview on page 28 of this report.

One indication of the pressure to transform is that the Danish sector giant Novo Nordisk has been forced to lay off employees due to pressure on prices in the USA after many years of recruiting new employees.

But it's about more than just pricing pressure. Novo Nordisk is currently in an interim phase; in 2017 the American Food and Drug Administration (FDA) approved the use of the GLP-1 drug Ozempic for the treatment of adult patients with Type II diabetes. For now, Ozempic is administered for treatment through weekly injections. Novo Nordisk is working to develop Ozempic in pill form however, so that patients can avoid using syringes. The new drug also results in significant weight loss, and studies are now being done to determine whether it can be used for the treatment of obesity and heart, kidney and liver diseases. Ozempic thus has all of the ingredients to become Novo Nordisk's next big selling drug.

For Copenhagen-based Lundbeck, the transformation became visible when a number of important patents expired in 2012–2014 and a series of new



PHOTO: LUNDBECK

products were being launched. The company develops pharmaceuticals aimed at improving the quality of life for people living with psychiatric and neurological disorders.

At Ferring, with its strong roots in the Øresund Region and its headquarters in Switzerland, owner Fredrick Paulsen speaks of new research platforms and collaborations that can transform the privately-owned family business.

At the life science sector's grand old company LEO Pharma, activities have been refined over the past decade, changing it from a conglomerate to a concentrated pharmaceuticals company focused on dermatology and the new generation of biological products and potentially gene therapy. CEO Gitte Aabo emphasises the importance of partnerships in development work and highlights the potential that new digital solutions offer through improved diagnostics with the use of artificial intelligence and big data, as well as apps that allow patients to follow the treatment progress of dermatological disorders with their mobile phones.

The common denominator for all four companies is renewal. This is also tangible when it comes to management; since 2016, new heads have been appointed for two of the four Danish beacons – Novo Nordisk and Lundbeck.

It can also be noted that setbacks in the life sciences in Sweden began years ago when the ownership of Astra and Pharmacia moved abroad, resulting in huge closures. It seems that the development has now changed direction in Sweden. A number of

new pharmaceutical factories have been established for biological production, and the state Swedish Research Council and the innovation authority Vinnova are investing over 100 million SEK to build up three new centres for R&D environments for biopharmaceuticals; the aim is to position Sweden as a leader in the field.

Today, Skåne lacks a large beacon company that can shoulder the role that AstraZeneca once filled with its former research facility in Lund. Medicon Village Science Park has been created in AstraZeneca's former buildings in Lund through the joint efforts of a regional industrialist, the university, and the region. The facilities are currently being expanded to make room for more research companies.

In Skåne however, there are positive developments for a number of small- and medium-sized companies. Biotech companies Camurus and Alligator Bioscience in Lund have enjoyed a number of research successes.

In Helsingborg, the Johnson & Johnson concern is investing 20 million USD in the expansion of

its subsidiary McNeil's operations (started up long ago by Danish LEO Pharma) in the city, with new production of asthma drugs as a complement to their existing anti-smoking products.

The Ferring offshoot Polypeptide continues to grow in Malmö, and today it is a thriving global company. There are also two flourishing companies focused on medtech in Malmö: Atos Medical and Arjo.

Government and industry investments

The life science industry in Denmark has been a lifesaver, both when it comes to exports as well as employment during the economic crisis, when it was the only sector to continue growing. In Sweden, the sector's successes were a bit further back in time.

The governments of both countries have come to the same conclusion however: the sector is important for growth and employment in the future. This is also apparent in the final negotiations for a new health reform that are currently being

made in Denmark. The reform is preceded by the government initiative in the life science field, which has entailed the establishment of a life science office at Denmark's Ministry of Industry,

"There are also high hopes in the region's life science sector when it comes to the new research facilities, European Spallation Source, ESS and MAX IV in Lund."

Lund University, University of Copenhagen, European Spallation Source, ESS, and MAX IV in Lund.



Business and Financial Affairs. Sweden has also prioritised the life sciences and is working toward a new strategy. Since February of this year, there is an Office for Life Science at the Government Offices of Sweden. The investments show that the life science sector is being prioritised on the national agendas of both countries.

The need to invest in steady renewal of research and entrepreneurship in the life sciences is also apparent in the industrial context. A clear example of this is the Novo Nordisk Foundation's major investment in the BioInnovation Institute, located at COBIS in Copenhagen.

– Why isn't research in Denmark generating more new companies? Why aren't more researchers interested in becoming entrepreneurs, so that society can make better use of their work?

These are questions that Thomas Nagy, director of the BioInnovation Institute, asks himself. Now the Novo Nordisk Foundation is investing 392 million DKK for three years to build BII into what they call "a world class innovation environment".

Medicon Valley's science parks have ushered in a new expansion phase, as an interim report from Medicon Valley Alliance and ØresundsInstitutet from June of this year shows. Among other things, DTU Science Park has changed its name from Scion DTU and expanded with a new incubator; Medicon Village has divided its activities into two companies that separate its innovation and its real estate operations, and is – like Medeon – constructing a new office building. Ideon's geographical footprint grew a couple of years ago, and it linked up with other real estate companies, and COBIS is now fully leased.

There are also high hopes in the region's life science sector when it comes to the new research facilities European Spallation Source, ESS, and MAX IV in Lund. ESS is a European endeavour with its data centre in Copenhagen and its research facility in Lund. MAX IV is a national, Swedish research facility, with Danish investments in beamlines. In the Leiden chapter of this report, the facilities are spotlighted as factors expected to contribute to increased trans-Øresund collaboration – not least when both are fully operational.

– Lund is at the very top when it comes to the universities we collaborate with internationally. Since the University of Copenhagen is close, it is one of our very strongest partners for collaboration, but Lund is also close. Research infrastruc-

ture like ESS and MAX IV also mean that we work together. When it comes to ESS in the region there's a whole lot of focus on the life sciences, and I think that many very exciting things are going to happen there, says Dean of Research Katrine Krogh Andersen from DTU.

A need for more joint research

The network analysis from the research institute CWTS shows that the region's national networks are significantly stronger than trans-Øresund networks, and in Medicon Valley national cooperation is far more common than cooperation between Denmark and Sweden. The analysis also shows that scientific publications co-published with international researchers are cited significantly more frequently than those published by researchers who worked independently or collaborated nationally.

More international collaboration is necessary if Medicon Valley as a cluster is to maintain its position as one of Europe's Top Ten. Vice-Chancellor of Malmö University Kerstin Tham offers a concrete suggestion for expanding collaboration in an interview on page 58: she believes that a joint life science strategy, for example for diabetes, an area in which the Danish and Swedish sides of Medicon Valley both perform comprehensive research, could help create a distinct profile for the region both nationally and internationally.

– One way to get started with a strategy in Medicon Valley for e.g. diabetes would be to hold a symposium in Brussels together with the businesses. I think it's important to start with something concrete, she says.

Some of the other suggestions made by university representatives interviewed for this report are targeted research funds for transborder collaboration and joint educational training for students to meet and get to know one another. It should be noted that both Lund and Malmö University discuss the possibilities of expanding collaboration with their Danish colleagues.

The collaboration can be seen in two dimensions: how the regional, trans-Øresund collaboration can be developed to strengthen the region in a European initiative; and how Medicon Valley's universities can reinforce European and global collaborations to reach the highest levels in research results. This can be compared with both Ferring and LEO Pharma, where strategies for the future are based on growth through the creation of productive, effective research alliances and collaborations.

APPENDIX: Facts and definitions

LARGER MEETINGS AND CONFERENCES

Below are some of the larger meetings and conferences being arranged in the Greater Copenhagen Region in the coming year, as well as a selection of international meeting places where representatives from organizations and companies in the region's life science cluster will be participating.

- 24 October 2018, Copenhagen
NOME Annual Meeting & Start-up Competition
- 24 October 2018, Gothenburg
Healthtech Nordic Investor Forum 2018
- 5-7 November 2018, Copenhagen
BIO-Europe
- 12-13 November 2018, Copenhagen
European Statistical Forum
- 14 November 2018, Boston
Drug Development Boot Camp 2018
- 12-15 November 2018, Düsseldorf
Medica
- 14-15 November 2018, London
4th Annual European Microbiome Congress
- 26-30 November 2018, Tokyo & Osaka
A Gateway to Japanese Healthcare
- 28-29 November 2018, New York
The Nordic-American Life Science Conference
- 4-5 December 2018, Lille
BioFIT 2018
- 12 December, Copenhagen
Børsen Medico Conference
- 13 December, London
Genesis 2018
- 28-31 January 2019, Dubai
Arab Health
- 14 February 2019, Rotterdam
Innovation for Health
- 15-19 March 2019, Barcelona
EAU19
- February 2019, Switzerland
Swiss Nordic Bio 2019
- 25-27 March 2019, Vienna
BIO-Europe Spring
- March 2019, Lund
The Future of Swedish and Danish Life Science
- September 2019, Stockholm
Nordic Life Science Days 2019
- November 2019, Copenhagen
Medicon Valley Alliance Annual Meeting

BIO-EUROPE TO COPENHAGEN IN NOVEMBER

From the 5-7 of November this year, the annual European life science conference and trade show BIO-Europe will be held in Copenhagen. This is the first time the conference is being held outside of Germany. The event will take place at Bella Center in Ørestad.

Last year's conference, held in Berlin, had around 4 000 visitors from 2 200 companies and

60 countries, and 100 exhibitors. The conference is arranged by EBD, partnered with – in addition to some of the region's larger companies – Copenhagen Capacity, Invest in Skåne, Event in Skåne, Wonderful Copenhagen, Medicon Valley Alliance, Malmö Convention Bureau, City of Malmö and Medeon Science Park & Incubator.

REPORTS AND FACTS



This report, “**State of Medicin Valley 2018**”, is an annual report, published for the first time in November 2016. The report has been prepared by the Danish-Swedish knowledge centre Øresundsinstituttet and commissioned by the network organisation Medicin Valley Alliance. The interim report “**Science Parks in Medicin Valley 2018**” was published in June 2018. Its focus was the life science-oriented science parks in Greater Copenhagen – which are expanding and reorganising.

In the following is a selection of the recent years' reports from the life sciences in Sweden, Denmark and Greater Copenhagen.

In July of this year, the Swedish government published “**Färdplan life science – vägen till en nationell strategi**” (Life Science Roadmap – The Path to a National Strategy) as a basis for work in the life sciences intended to result in a national strategy for the area. Among other things, the report highlights personalised medicine as an important area for development. As of February of this year, there is an Office for Life Science at Sweden's Government Offices. Jenni Nordborg is at the helm.

In March of this year, the Danish government presented its “**Vækstplan for life science – Danmark som førende life science nation**” (Growth Plan for Life Science – Denmark as a Leading Life Science Nation), which involves strengthening life science by allocating 30 billion DKK annually until 2021. Among other things, the plan includes tax deductions for companies that invest in research, more initiatives to attract a qualified labour force, and a new life science unit established in the Ministry of Economic and Business Affairs.

The Swedish agency Growth Analysis published the report “**Den svenska life science industrins**

utveckling – statistik och analys” (Development of the Swedish Life Science Industry – Statistics and Analysis), which shows among other things that the sector comprised more than 42 000 employees at over 3 000 companies in 2016. From 2014–2016, life science companies' exports rose 15%, the report shows.

In June, the Danish trade association Lif published the annual summary “**Lægemedelindustriens nøgletal**” (The Pharmaceutical Industry's Key Figures), which shows among other things that the pharmaceutical industry employs 26 000 people in Denmark and contributes 13.8% of Danish good exports. According to Danish Medicoindustrien's report “**Medicobranschen i tal 2017**” (The Medico Sector in Figures), employment in the medico sector increases 5.5% annually, and productivity is almost double industry's levels in general.

This year, the trade association SwedenBio published a new report entitled “**Precision Medicine – The Swedish Industry Guide 2018**” (in English), which is an overview of the Swedish companies active in the sector.

In March, the Confederation of Danish Industry (DI) published the summary “**Sundhedseksporten sætter skub i dansk økonomi**” (Health

Exports Boost Danish Economy), which shows for example that employment and exports in the Danish health industry have increased almost every year since 2008. A report from the same organisation about research and development investments in Danish companies shows that Novo Nordisk tops the list in Denmark, coming in 67th in the world with 14.9 billion DKK in R&D in 2017. The report is part of a series on the topic, and is called “**Danmark tilbage på videnssporet IV**” (Denmark Back on the Knowledge Track IV). According to yet another report from DI, “**Flere ældre kan øge dansk eksport af sundhedsprodukter**” (More Elderly Can Increase Danish Health Product Exports), exports of Danish health products can increase by 40 billion DKK by 2035 as a result of an increase in the number of elderly in important export markets.

Swedish Industrifonden released “**Scandinavian Life Science Funding Report 2017**” (in English) in January of this year. It shows that Scandinavian life science companies raised twice as much capital in 2017 than in 2016. According to the report, Stockholm is responsible for 85% of the total Scandinavian funding.

In its “**Lägesrapport 2018 – Sveriges satsningar på medicinsk forskning**” (Status Report –

Sweden's Investments in Medical Research), the foundation Forska!Sverige warns that the number of pharmaceutical trials begun in Sweden between 2004 and 2016 has dropped by half. That can, according to the foundation, impact access to new, effective pharmaceuticals.

In May, the three trade organisations LIF, Swedish Medtech and SwedenBio presented “**Handlingsplan för Life Science – för ett konkurrenskraftigare Sverige**” (Life Science Plan of Action – for a Competitively Stronger Sweden). 19 measures are suggested in the plan of action, among them lowering export tax like the Danish, and that university health care be given the task of early introduction of innovative treatments.

The International Federation of Pharmaceutical Manufacturers & Associations, IFPMA, published the report “**50 Years of Global Health Progress**” (in English) this May. It concerns the developments regarding e.g. vaccines, HIV/AIDS, diabetes and cancer over a 50-year period.

The European Federation of Pharmaceutical Industries and Associations, EFPIA, launched “**2018: The Pharmaceutical Industry in Figures**” (in English), which shows that the European pharmaceutical industry employs 750 000 people and invests an estimated €35 200 million in R&D.

ORGANISATIONS

PHOTO: NEWS ØRESUND



Claus Lønborg from CEO Copenhagen Capacity, who, with Invest in Skåne, is responsible for a campaign to attract more life science talent to the region.

TRADE AND NETWORKING ORGANISATIONS:

- **ASCRO** – Swedish association focused on clinical research and clinical trials
- **Cluster Excellence Denmark** – a support function for clusters and innovative networks in Denmark co-funded by the Danish Agency for Institutions and Educational Grants and the regions
- **CHC**, Copenhagen Healthtech Cluster – Danish organisation that aims to create growth opportunities within health care
- **CHI**, Copenhagen Health Innovation – Danish organisation focused on developing new educational and development activities within health care
- **Dansk Biotech** – Danish trade organisation for companies in biotechnology
- **EuropaBio**, the European Association for Bioindustries – European trade organisation for the biotechnology industry
- **EFPIA**, European Federation of Pharmaceuticals Industries and Associations – European trade association for the pharmaceutical industry in Europe
- **FOIN**, the Association of Innovative Settings in Denmark – Danish trade association for science parks and innovative settings, formerly Forskerparkforeningen/The Science Park Organisation
- **Healthcare Denmark** – Danish organisation with political mandate to market the Danish health care sector
- **IFPMA**, International Federation of Pharmaceutical Manufacturers & Associations – international trade association for pharmaceutical companies and associations
- **Kemi & Life Science** – Danish trade community and network for distributors and manufacturers of chemicals
- **Lif Danmark** – Trade association for the pharmaceutical industry
- **Lif Sverige** (researching pharmaceutical companies) – Trade association for manufacturers of pharmaceuticals
- **Medicoindustrien** – Danish trade association for companies that produce, sell, or have an interest in medical equipment
- **MVA**, Medicon Valley Alliance – Networking and member organisation in the Danish-Swedish life science cluster Medicon Valley in Greater Copenhagen

- **Swecare** – Swedish member organisation that works for broad collaboration with the health and health care sectors
- **SwedenBIO** – Swedish trade association for the life science sector
- **Swedish Labtech** – Swedish trade association for companies working in diagnostics, laboratory equipment, analysis and biotechnology
- **Swedish Medtech** – Swedish trade association for medical technology
- **SISP**, Swedish Incubators & Science Parks – Swedish trade association for incubators and science parks
- In addition, there are the broader trade organisations Dansk Industri (Confederation of Danish Industry) and Dansk Erhverv (Danish Chamber of Commerce) and Handelskammaren (Sweden's Chamber of Commerce) and Svenskt Näringsliv (Confederation of Swedish Enterprise).

PUBLIC ACTORS:

- **Copenhagen Capacity** – A public initiative to promote investments and economic development in Greater Copenhagen
- **Erhvervsstyrelsen** – Danish business authority that works to improve companies' competitive strength
- **Innovationsfonden** – Fund from the Danish Ministry of Higher Education and Science that invests in new knowledge initiatives
- **Invest in Skåne** – A public initiative to attract foreign investments to the region, promote exports and internationalisation for companies in the Skåne Region
- **Läkemedelsverket/Medical Products Agency** – Swedish authority that tests and approves pharmaceuticals
- **Lægemiddelstyrelsen /Danish Medicines Agency** – Danish authority that tests and approves pharmaceuticals
- **Patent- och registreringsverket/Swedish Patent and Registration Office** – Swedish authority for intellectual property rights
- **Danish Patent and Trademark Office/Patent- og Varemærkestyrelsen** – Danish authority for intellectual property rights
- **Styrelsen for Forskning og Innovation** – Danish authority that works to strengthen research and innovation
- **The Government Offices of Sweden's coordinating Office for Life Science** – was established in February this year and is working among other things with a new life science strategy.
- **The life science office at Denmark's Ministry of Industry, Business and Financial Affairs** – the government office responsible for the implementation of the Danish national strategy for life science.
- **Tillväxtverket** – Swedish authority to strengthen companies' competitive strength

- **Tillväxtanalys** – Swedish authority with tasks such as analysing and evaluating Swedish growth policies
- **Vetenskapsrådet** – Swedish authority that works to develop Swedish research
- **Vinnova** – Swedish authority that works to improve opportunities for innovation and research
- **Wonderful Copenhagen** – Danish organization working to attract e.g. life science conferences to the Medicon Valley region

MEDIA:

- **Dagens medicin** – Swedish journal about the health care sector
- **Dagens medicin, Dagens Pharma, Kommunal Sundhed and Praktisk medicin** – Danish journals about the health care sector
- **European Biotechnology News** – European journal about life science
- **Greater Copenhagen Life Science Magazine** – Scandinavian life science magazine published by the Danish marketing and advertising agency Nem Media
- **Kemivärlden Biotech** – Scandinavian journal for chemistry, chemical engineering and biotechnology
- **Labitech.eu** – European news site on the biotechnology industry
- **Life Science Sweden** – Journal on the Swedish biotechnology, medical technology and pharmaceutical industries
- **Medwatch** – Danish news site on the medical and pharmaceutical industries
- **Nordic Life Science News** – journal and news site on the Nordic life science industry
- **Pharma Industry** – Swedish trade journal for the pharmaceutical industry

SCIENCE PARKS IN MEDICON VILLAGE THAT COMPLETELY OR SIGNIFICANTLY FOCUS ON THE LIFE SCIENCES:

- **DTU Science Park** – focus on deep tech. Located in Hørsholm and Lyngby. Formerly known as Scion DTU.
- **Cobis** – focus on life science. Located in Copenhagen. Owned by DTU Science Park and Symbion.
- **Symbion** – focus on life science, foodtech, edtech, hardware/makerspace and SaaS. Located in Copenhagen.
- **Ideon** – focus on future transportations, smart cities, smart materials and health tech. Located in Lund.
- **Krinova** – focus on food, the environment and health. Located in Kristianstad.
- **Medeon** – focus on life science. Located in Malmö.
- **Medicon Village** – focus on life science. Located in Lund.

LEARNING AND RESEARCH INSTITUTIONS IN MEDICON VALLEY WITH ACTIVITY IN THE LIFE SCIENCES:

- **University of Copenhagen** – A large university with departments for health and medical sciences, science, humanities, law, social sciences and theology.
- **Technical University of Denmark (DTU)** – A technical university in Kongens Lyngby, just north of Copenhagen.
- **Roskilde University** – A university in the middle of Zealand with emphasis on transdisciplinarity.
- **Aalborg University in Copenhagen** – A campus of Aalborg University in Jutland with a broad range of departments.
- **The National Institute of Public Health (NIPH), University of Southern Denmark** – A research institution that is part of the University of Southern Denmark, but also serves the Danish authorities, supporting them with research and counsel on public health.
- **CBS** – A university in Copenhagen with focus on economics, as well as educational training in Business Administration and Bioentrepreneurship.
- **Copenhagen School of Design and Technology** – An institute of higher education in Copenhagen with some research in optometry.
- **Capital Region of Denmark** – The region encompasses a large number of hospitals, predominantly in Copenhagen and northern Zealand. The largest of them is Rigshospitalet.
- **Region Zealand** – The region encompasses a number of hospitals, primarily in Zealand and Lolland. The most important of them is Zealand University Hospital in Roskilde and Køge.
- **The State Serum Institute, Copenhagen** – A research institution of the Danish Ministry of Health. Its focus is on diagnostics, epidemiological monitoring and vaccination research.
- **The Danish Cancer Society, Copenhagen** – A patient organisation to fight cancer. With a research centre in Copenhagen.
- **Lund University** – A large university with departments for medicine, science, technology, the humanities, law, economics, theology, art, music and theatre.
- **Malmö University** – A new university with a transdisciplinary focus.
- **The Swedish University of Agricultural Sciences in Alnarp** – One of the largest campuses of the Swedish University of Agricultural Sciences, which has campuses throughout Sweden. Its main areas are landscape architecture, horticulture and plant production.
- **Kristianstad University** – A college in north-eastern Skåne with a strong focus on education.
- **Region Skåne** – The region encompasses a number of hospitals in Skåne, the largest of which is Skåne University Hospital in Lund and Malmö.

Statistics and methodology

Describing the life science sector with statistics is a challenge. The sector is far from homogenous, and there are shifts over time. There are only five sub-areas designated in the national statistics as exclusively life science sectors; the remainder are spread out over a long string of sector codes. The same is true for the universities where life science is not a clearly defined research area. Therefore, the exclusive use of statistics from the national statistics offices cannot provide a sufficiently complete and comprehensive representation. We have thus also chosen to complement the statistics with facts from the Nordic Business Key, as well as information provided by the companies and universities themselves.

The macro-level numbers in this report and certain special figures, such as for example domestic and international students, have been specially requested from Statistics Denmark and Statistics Sweden. We have used the following statistic divisions to define the life science sector and export of life science products:

SNI and DB07-sector codes are exclusive to life science sectors, used for figures regarding employment:

21 Manufacture of basic pharmaceutical products and pharmaceutical preparations
26.60.10 Manufacture of hearing aids and supplies
26.60.90 Manufacture of irradiation, electromedical and electrotherapeutic equipment
32.5 Manufacture of medical and dental instruments and supplies
46.46.10 Wholesale trade of medical goods and nursing supplies.

The following codes are used for the description of scientific research and employment:

72.11 Research and experimental development in biotechnology
72.19 Other research and experimental development in natural sciences and engineering.
These two industries encompass companies with research in natural sciences as their main purpose and not life science production companies.

Some of these are life science companies; however, since the sectors also contain research within other areas than life science, the sectors are not included in the figures for employment in the life sciences, but are instead presented separately.

The commodity groupings (SITC) in trade statistics utilised to describe exports:

54 – Medical and pharmaceutical products
872 - Medical Instruments and appliances and similar

ABOUT THE FIGURES

TAXATION, PAGES 10-23

Defining the Danish life science sector to calculate taxes

In the statistics for the number of employees in the life science sector, the sector is defined according to the

sector of the workplaces. This definition cannot be used in the calculation of the sector's tax contributions, since corporation tax is paid on the company/concern level, and the main sector of a workplace does not necessarily correspond to the company's main sector. The following method has thus been used:

1. For each year, the number of full-time employees who work at a workplace whose main sector is life science is tallied.
2. Information is retrieved for the companies/concerns to which these workplaces belong. The number of employees who work in life science branches at these workplaces is tallied, as well as the number of employees on the company/concern level.
3. For a given year, a company/concern in the life science sector is included if:
 - a. The company/concern has employed more than 50% of its employees at workplaces in the life science sector during the year in question; or
 - b. The company/concern meets criterion a) throughout the entire period 2008-2016 for the majority of its active period.
 It has been necessary to include criterion b) in order to encompass companies/concerns that pay taxes via a holding company certain years, and in others via the producing company.

The source for the Swedish figures of income and corporation tax is the FRIDA database. FRIDA is a combined individual database and firm register for all Swedish companies. The life science sector has been defined according to the sector of the company's headquarters.

Corporation tax

Corporation tax for Danish life science companies is defined as the corporation tax paid by companies/concerns that fulfil the above criteria. For Sweden corporation tax is the company's final tax, which consists of state tax (bodelagsskatt) on the year's result (22% of reported surplus) plus other taxes that may be applicable, e.g. yield tax.

Income tax

Income tax for people employed in the life science sector is defined for people employed in the companies/

concerns that fulfil the criteria described in 'Defining the Life Science Sector'. Geographically, income tax is determined according to where the income is earned, and not where the employee resides. Thus, border commuters from Sweden are included in the analysis of Danish income tax. Residents of Denmark who work abroad are in turn not included in the analysis of Danish income tax.

Income tax is calculated from the total personal income; i.e. it includes income from salary and self-employment, as well as any transfers of income that are subject to taxation.

In Denmark, income tax is equivalent to the total personal final tax on income, including labour market contributions. The total personal final tax includes state tax, health care tax, municipal tax, preliminary corporation tax, tax on stock dividends and stock profit, and labour market contributions. Final tax is determined after the deductions have been made and various tax additions have been included.

The amount of labour market contributions paid for employees in the life science sector is calculated by inferring that the labour market contributions comprise the same share of the total income tax, including labour market contributions, for the life science sector in its entirety as for the economy as a whole. The income tax, excluding labour market contributions, for employees in the life science sector is divided by the share of the total income tax including labour market contributions, comprised by the labour market contributions for the economy as a whole, to calculate the income tax including labour market contributions for employees in the life science sector.

In Sweden, income tax is equal to the total income tax on gainful employment. The source for this data is

the Swedish income register for the period 2008-2016. Income from gainful employment includes income from a position of staff employment including benefits, surplus from business operations, sickness benefits, unemployment benefits and pension income after general deductions. These may be social security duties to another country, alimony or social contributions.

Income and corporation tax comprise only part of the amount contributed to the treasury through taxes and duties; of which value-added tax is the absolute largest in both countries. In Sweden, duties and other taxes include e.g. a municipal property tax, burial tax, duties to religious communities, vehicle tax and a series of excise duties on e.g. alcohol and tobacco. In Denmark there are a large number of taxes and duties in addition to corporation tax and income tax, for example municipal property tax, which is calculated based on value, registration duties on cars and a number of excise duties on other products such as tobacco, wine, spirits, chocolate and sugar.

EXPORT, PAGES 10-23

The figures for the global pharmaceuticals market are the amounts invoiced to pharmacies and hospitals by distributors. Those amounts are not equivalent to the amounts that manufacturers of pharmaceuticals receive for their products; discounts and other price agreements are not included.

The source for the information on the global market is IQVIA. The source for the global market export is the UN Comtrade database and figures for the Danish and Swedish life science export is retrieved from Statistics Denmark and Statistics Sweden, respectively.

The Danish and Swedish life science sectors' exports are calculated as the export of Medicinal and pharmaceutical products (SITC 54), as well as Instruments and appliances, n.e.s., for medical, surgical, dental or veterinary purposes (SITC 87.2). The SITC classification is the UN's classification system for goods (Standard International Trade Classification). The sources are the foreign trade statistics from Statistics Denmark and Statistics Sweden, respectively.

EMPLOYMENT, PAGES 10-23

The employment figures cover the manufacturing sectors: 21 Pharmaceuticals, 26.60.10 Manufacture of hearing aids and supplies, 26.60.90 Manufacture of irradiation, electromedical and electrotherapeutic equipment, 32.50.00 Manufacture of medical and dental instruments and supplies and 46.46.10 Wholesale of pharmaceutical and nursing goods. The sources are the register-based Labour Force Statistics in Denmark (RAS) and in Sweden (RAMS). Statistics Denmark and Statistics Sweden utilise national industry classification (DB07) and (SNI2007), both of which are based on and correspond to the European industry classification NACE. A company can perform business that is within more than one sector classification. In such cases, the company has a main sector and one or more additional sectors. In the register-based Labour Force Statistics, all of a company's

SECTOR CLASSIFICATION

The definition of life science that we have used here is considered the most widespread, and is utilised by several trade organisations. For example, as SwedenBIO formulates it:

- **BIOTECHNOLOGY COMPANIES** develop products that are based on biological material such as cells, proteins and DNA.
- **PHARMACEUTICAL COMPANIES** develop pharmaceuticals. These may be large biological molecules or small chemical molecules.
- **MEDICAL TECHNOLOGY COMPANIES** develop technological products to improve people's health or make the everyday easier for those who are ill. Companies that develop diagnostic methods are often assigned to this category. Diagnostics products are used to analyse samples and tests to make a correct diagnosis.

employees are registered under the company's primary sector. An example is Coloplast, whose main sector is 21 Pharmaceuticals, and also has the following three additional sectors: 32.50.00 Manufacture of medical and dental instruments and supplies, 22.29.00 Manufacture of other plastic products, and 46.46.10 Wholesale of pharmaceutical and nursing goods.

Note that it is also possible that branch codes are assigned to companies differently in Denmark and Sweden.

Other industry subdivisions of the life science sector cannot be extracted, as they are placed within service sectors such as business services, which covers a significantly broader area than life science. The advantage of using the narrow definition of the sector is that it becomes possible to trace the industry's development over time, as well as to draw European and international comparisons. The disadvantage is that the life science industry is not shown in its entirety. Therefore, the figures are supplemented by figures for employees at life science companies not covered by the national statistical figures from Statistics Denmark and Statistics Sweden; an example of a company that we have supplemented with employee figures is Novozymes. The supplementary information has been collected from the relevant companies either via email, telephone or via the company website; from Nordic Business Key; www.allabolag.se; or from news articles.

PATENTS, PAGES 10–23

For patent applications figures from EPO and EUROSTAT for patent applications to the European Patent Office (EPO) distributed by priority date and publication date are used. Normally, a patent application to EPO is preceded by an application to the national patent office. The filing date for the application to the national patent office is the priority date for the subsequent application to EPO. The publishing date for a patent application to EPO is usually 18 months after the priority date. Patent information from United States Patent and Trademark Office (USPTO) is rather old at the time of publishing, and for that reason it has been chosen primarily to present data for EPO, even though the interest in patent applications at USPTO has grown as a consequence of the growth of the American medical market.

UNIVERSITIES, RESEARCH INSTITUTIONS AND REGIONS, PAGES 50–51 AND 60–62

Figures for the number of researchers and students have been provided by the universities, regions and research institutions themselves and are based on the most recent figures available.

University of Copenhagen. Life science researchers: head count. Number of doctoral students at departments and centers with life science activities.

Lund University. The numbers apply only to the Faculty of Medicine, as information could not be obtained from the Faculty of Science or the Faculty of Engineering. Of the doctoral students, 369 are employed at Lund University, so only this number has been counted in the

total number of life science researchers. The others are part-time doctoral students employed by Region Skåne.

Technical University of Denmark (DTU). Information is for the researchers at the following departments: DTU Food, DTU Vet, DTU Aqua, DTU Biosustain, DTU Bioinformatics and DTU Bioengineering and an equivalent selection of students.

The Swedish University of Agricultural Sciences in Alnarp. The decrease in the number of researchers and students since the last report is due to a more narrow definition of life science and a different calculation method.

Malmö University. Life science students: full-time equivalents.

Roskilde University. Figures from the turn of the year 2016/17.

Aalborg University in Copenhagen. Figures from 2017.

The Capital Region of Denmark. The number of researchers indicates people who dedicate at least 10% of their working hours to research – often, but not always – in the life sciences. A number of researchers also have part-time positions at the University of Copenhagen. Doctoral students also include research fellows.

Region Skåne. All professors also have part-time positions at Lund University. Head count for researchers – many conduct research part-time.

Region Zealand. Head count for researchers – many conduct research part-time.

The Danish Cancer Society. Seven professors also have part-time positions at the University of Copenhagen as associate professors.

The State Serum Institute. Head count.

INTERNATIONAL RESEARCHERS AND STUDENTS, PAGE 63–64

International students

The figures for the number of students and their connection to the job market are retrieved from customised analyses by Statistics Denmark and Statistics Sweden. The selection of educational programmes was made from the programme classifications in Denmark and Sweden, and programmes have been chosen within which work in the sector is usually found after education is completed.

The figures for Denmark and Sweden are not directly comparable due to differences in the educational systems and the available data material.

The Danish and Swedish educational systems are structured differently. In Denmark, students – apart from exchange students – register for an entire programme at the bachelor or graduate level. In Sweden, it is possible to register for individual courses, and it is also possible to complete a master's degree by combining individual courses from different programmes. The criterion is that one must earn 120 ECTS points to complete a master's degree. A student who has registered for two courses in the same semester will thus be accounted for two times in the statistics. An attempt has been made to account for this in the extracts from the Swedish data. Students re-

gistered for more than one course at the same institution are only counted as one student; however, if that student is registered for courses at two separate institutions, s/he will be accounted for twice in the data material. The figures for the number of students are thus not directly comparable between Denmark and Sweden.

The definition of an international student depends on national definitions and the possibilities offered in the dataset at hand. Therefore, the definition differs in Danish and Swedish data extractions. In Sweden, an international student is defined as 1) a person from a country outside of the EU/EEA, who upon moving to Sweden reported that the move was motivated by studies, and where a residency permit has been issued for less than two years before the commencement of studies; 2) students who have moved to Sweden less than six months prior to the commencement of studies; and 3) other individuals lacking a Swedish personal identification number in the educational institutions' study administration systems. In Danish data, an international student is defined as such if s/he came to Denmark within a period from one year prior and three months after commencement of studies, and does not have a Danish secondary education.

International researchers

Data for foreigners who have not completed their education in the country are incomplete in the national statistics office's register of the population's education. Because of the poor data quality on the education of workers who have come to Denmark from abroad it has been necessary to use additional sources such as the utilisation of the tax relief schemes, and the Danish Agency for Labour Market and Recruitment's database Jobindsats.dk.

It is not possible to extract specific data material for the life science sectors in Medicon Valley from the data sources used here; however, by the use of the available complementary Danish sources, the Danish life science sector's need for highly qualified workers from abroad

becomes clearly visible. The Danish Ministry of Taxation and the Forskarskattenämnden websites offer statistics about the utilisation of the tax relief scheme.

MISCELLANEOUS

We have also collected information from personal interviews, telephone interviews and in e-mail contact with experts and companies. This applies, among others, to the chapter on beacons. Data for the reviews of companies has been retrieved from Bisnode, through contact with the companies and from their websites, as well as from media reports. We have also utilised the public investigations from within life science, as well as other reports from public actors and trade and networking organisations.

CLUSTER RANKING:, PAGES 32–65

Selection of life science clusters

Medicon Valley Alliance has chosen to commission an analysis from the Centre for Science and Technology Studies (CWTS) of Leiden University.

For technical reasons, CWTS recommended a comparison of European clusters rather than of clusters around the globe. CWTS uses NUTS-coding to identify European clusters, and would not be able to work with the same precision for clusters around the world. The result is also a more consistent range of clusters with which to compare Medicon Valley.

To identify relevant life science clusters in Europe, Øresundsstatistik, which has prepared the report for Medicon Valley Alliance, compiled a number of sources. The selection process was based on the Leiden Ranking from 2012–2015 (which was the most recent available ranking at the time of the selection), which is independent of the consultant report later produced by CWTS. It investigated the locations or geographic areas in which the first 25 universities on the European list of the greatest number

THE EFFECT OF SECTOR DRIFT AND SECTOR CHANGE

Statistics for the number of employees in the life science sector are based on figures from the register-based Labour Force Statistics in Denmark (RAS) and in Sweden (RAMS). The employment figures cover the manufacturing sectors: 21 Pharmaceuticals, 26.60.10 Manufacture of hearing aids and supplies, 26.60.90 Manufacture of irradiation, electromedical and electrotherapeutic equipment, 32.50.00 Manufacture of medical and dental instruments and supplies and 46.46.10 Wholesale of pharmaceutical and nursing goods. Sector drift and sector changes for individual companies can affect

the figures to a greater or lesser degree. The more detailed statistics are for individual sectors and smaller geographic areas, the more visible sector drift and change of sector become. A sector drift is a slow change in a company's product portfolio that eventually leads to it belonging to a different sector than it did originally. A change of sector is the switch to another sector code without changes to the company's product portfolio.

State of Medicon Valley 2017 contains an example (Coloplast) of how sector code can change over time.

of scientific articles in the field “Biomedical and Health Sciences” are situated. While “Biomedical and Health Sciences” does not encompass the area identified as life science in CWTS’ analysis completely, it is decisively the category that corresponds most closely. Earlier reports were then consulted with the aim of identifying additional locations or geographic areas with life science clusters. The following reports were consulted:

- “The Leading Life Sciences Clusters in Europe”, prepared by SANOFI on behalf of Science Business 2015.
- “Evaluation of Future Opportunities in Medicon Valley”, prepared by The Boston Consulting Group on behalf of Medicon Valley Alliance 2012.
- “New Home for the European Medicines Agency”, prepared by KPMG on behalf of Novo Nordisk 2017.

Using these reports, we identified cluster areas that were not linked to a university on the top-25 list in Leiden’s Ranking of “Biomedical and Health Sciences”, or that are transborder, but have strong research in the life sciences on the whole.

For each cluster, we conducted online research to ensure the existence of a cluster organisation or confirm that the area or location in question is locally recognised as a cluster. As there is no simple definition of a cluster, some clusters have a larger scope than others. A crystal clear definition in this area is almost impossible.

Departing from the above parameters, we compiled the following list of clusters in Europe whose universities published the greatest number of scientific articles in “Biomedical and Health Sciences” from 2012-2015 (currently the most recent available period). Arranged according to the number of articles in the ten per cent most frequently cited articles, the clusters are:

- London-Cambridge-Oxford
- The Netherlands
- Paris / Île de France
- Flanders
- Stockholm-Uppsala
- Scotland
- Medicon Valley
- Zurich
- BioValley (a German-French-Swiss cluster including Basel, Alsace, Freiburg, Karlsruhe, Mulhouse, Strasbourg)
- Munich
- Rome
- Berlin
- Heidelberg
- Barcelona
- Milan

Of these, we have chosen to compare the first ten clusters on the list, which CWTS identified according to the following NUTS code definitions:

- London-Cambridge-Oxford: UKH1, UKH2, UKH3, UKI and UKJ1

- The Netherlands: the entire country
- Paris/Île de France: FR10
- Flanders: BE21, BE22, BE23, BE24, BE25 and BE10
- Stockholm-Uppsala: SE11 and SE12, except Linköping University, Örebro University and Mälardalen University College
- Scotland: the entire country
- Medicon Valley: SE22, DK01 and DK02, except Blekinge Institute of Technology
- Zurich: CH04
- BioValley: CH03, FR42, DE11, DE12, DE13 and DE14
- Munich: DE21 and DE27, except Neu-Ulm University of Applied Sciences and Kempten University of Applied Sciences

All scientific publications in the relevant categories from every region have been included, regardless of whether the research was performed at e.g. a university, a university hospital, or other research institutions or commercial enterprises.

Selection of the bibliometric database

CWTS conducted its analysis in an in-house version of Web of Science:

“Our CWTS Citation Index (CI) system will be used for these analyses. The core of this system is comprised of an enhanced version of Clarivate’s citation indexes: Web of Science (WoS) version of the Science Citation Index, SCI (indexed); Social Science Citation Index, SSCI and Arts & Humanities Citation Index, AHCI.

We therefore calculate our indicators based on our in-house version of the WoS database. WoS is a bibliographic database that covers the publications of about 12 000 journals in the sciences, the social sciences, and the arts and humanities.”

Definition of life science

CWTS has limited its bibliometric analysis to encompass only publications within the category life sciences. They define this category as follows:

“... all the publications selected for these regions were limited to those that are designated to the higher level category of ‘Medical and Life Sciences’. This category is a derivative of those Web of Science categories that adhere to the moniker that was defined for this higher level field of science. This is to some extent an arbitrary process in which choices are made on the basis of best practice and educated assumption.”

The complete list of categories is as follows:

For a more detailed description of the methodology, please refer to the report “CWTS Bibliometric Report: Benchmark Life Science Regions Research for Øresund Institute 2006-2016/17” by Erik van Wijk, 2018.

*van Wijk, Erik (2018): “CWTS Bibliometric Report: Benchmark Life Science Regions Research for Øresund Institute 2006-2016/17”

Web of Science Categories in 'Medical and Life Sciences'		
Agricultural engineering	Engineering, biomedical	Ophthalmology
Agricultural experiment station reports	Entomology	Ornithology
Agriculture, dairy & animal science	Evolutionary biology	Orthopedics
Agriculture, multidisciplinary	Fisheries	Otorhinolaryngology
Agronomy	Food science & technology	Parasitology
Allergy	Gastroenterology & hepatology	Pathology
Anatomy & morphology	Genetics & heredity	Pediatrics
Andrology	Geriatrics & gerontology	Peripheral vascular disease
Anesthesiology	Gerontology	Pharmacology & pharmacy
Audiology & speech-language pathology	Health care sciences & services	Physiology
Behavioral sciences	Health policy & services	Plant sciences
Biochemical research methods	Hematology	Primary health care
Biochemistry & molecular biology	Horticulture	Psychiatry
Biology	Immunology	Public, environmental & occupational health
Biophysics	Infectious diseases	Radiology, nuclear medicine & medical imaging
Biotechnology & applied microbiology	Integrative & complementary medicine	Rehabilitation
Cardiac & cardiovascular systems	Marine & freshwater biology	Reproductive biology
Cell & tissue engineering	Materials science, biomaterials	Respiratory system
Cell biology	Mathematical & computational biology	Rheumatology
Chemistry, medicinal	Medical informatics	Social work
Clinical neurology	Medical laboratory technology	Soil science
Critical care medicine	Medicine, general & internal	Sport sciences
Dentistry/oral surgery & medicine	Medicine, research & experimental	Substance abuse
Dermatology	Microbiology	Surgery
Developmental biology	Mycology	Toxicology
Emergency medicine	Neuroimaging	Transplantation
Endocrinology & metabolism	Neurosciences	Tropical medicine
	Nursing	Urology & nephrology
	Nutrition & dietetics	Veterinary sciences
	Obstetrics & gynecology	Virology
	Oncology	Zoology

INTERVIEW LIST

- **Gitte Aabo**, CEO LEO Pharma, meeting, 22 Febr. 2018
- **Bo Åhrén**, Pro Vice-Chancellor, Lund University, meeting, 7 Sept. 2018
- **Erik Bisgaard Madsen**, Dean, Associate dean for Trade and Government Collaboration, Faculty of Science – University of Copenhagen, telephone, 24 Aug. 2018
- **Mogens Holst Nissen**, Vice Dean for Research, Faculty of Health and Medical Sciences – University of Copenhagen, telephone, 20 Aug. 2018
- **Katrine Krogh Andersen**, Dean of Research, DTU, meeting, 4 Sept. 2018
- **Olle Ljungqvist**, Professor of Surgery, Örebro University Hospital, telephone, 11 Sept. 2018
- **Thomas Nagy**, Director BioInnovation Institute, meeting, 31 May 2018
- **Frederik Paulsen**, Chairman, owner Ferring, telephone, 25 May 2018
- **Kerstin Tham**, Vice-Chancellor, Malmö University, meeting, 17 Sept. 2018
- **Trine Winterø**, Vice Dean of Innovation & External relations, Faculty of Health and Medical Sciences – University of Copenhagen, telephone, 20 Aug. 2018

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Behind the report:

MEDICON VALLEY ALLIANCE AND ØRESUNDSINSTITUTTET

Øresundsinstitutet and Medicon Valley Alliance have a long-term analysis collaboration. State of the Region is an annual analysis of the developments in Medicon Valley. In addition to this annual report, we publish a special report every year; this year's topic was "Science Parks in Medicon Valley". Medicon Valley Alliance and Øresundsinstitutet are both member-based, and a selection of the member-actors are represented in the board of directors.

Board of directors:



MEDICON VALLEY ALLIANCE (MVA) is a non-profit membership organization in the Danish-Swedish life science cluster Medicon Valley, which is a part of Greater Copenhagen. Our 260 members, who together employ approximately 140 000 people, represents the region's triple-helix and include universities, hospitals, human life science businesses, regional governments and service providers.



Board of directors:



ØRESUNDSINSTITUTTET is an independent Danish-Swedish centre for analytics and information that brings together more than 100 actors from the industry, the public sector and academic institutions with the aim of strengthening knowledge about societal developments on both sides of the Øresund Strait. As a member of Øresundsinstitutet, you become part of our strong Danish-Swedish network – and gain access to network meetings, facts, analyses and news about developments in the Greater Copenhagen region.



The analysis "State of Medicon Valley" is prepared by Øresundsinstitutet and commissioned by Medicon Valley Alliance.

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MEDICON VALLEY ALLIANCE

MVA is a Gold Label-certified, non-profit member organisation in the Danish-Swedish life science cluster Medicon Valley. Its 250 members include universities, hospitals, human life science businesses, regional governments and service providers that employ approximately 140 000 people and represent the Region's 'double triple-helix'. The activities in MVA focus on strengthening collaborations for a vibrant life science ecosystem in Medicon Valley through networking events and increased collaboration across borders and sectors.

THE VISION

The vision is to be a well-known and respected member-driven contributor to the realisation and positioning of Medicon Valley as the most competitive and vital life science cluster in Northern Europe.

THE MISSION

MVA is committed to realising Medicon Valley's potential by facilitating networking, knowledge-sharing, and collaboration, analysing challenges and potentials, and mobilising support from key opinion leaders.

CALL TO ACTION

Read more about the Danish-Swedish life science cluster organisation Medicon Valley Alliance's events and activities on www.mva.org, where you can also find more information about how YOUR company can benefit from a membership.

