

# RESEARCH IN MEDICON VALLEY 2017

An Analysis of Life Science Research at Universities in Greater Copenhagen

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Creating Opportunities

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An Analysis of Life Science Research at Universities in Greater Copenhagen

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Creating Opportunities

#### PREFACE

You are now about to read an MVA analysis titled "Research in Medicon Valley 2017 – An Analysis of Life Science Research at Universities in Greater Copenhagen. This publication is the result of an analysis collaboration between Medicon Valley Alliance and The Øresund Institute and as such it is a university focused in-depth follow-up to the more general "State of Medicon Valley 2016 – An Analysis of Life Science in Greater Copenhagen" published in November 2016.

Obviously, the volume and quality of universities' R&D and their interaction with the two other pillars in the region's life science triple helix structure, the hospitals/regions and the industry, are of crucial importance for the Medicon valley life science eco-system.

This analysis serves several purposes. Firstly, it introduces a methodology by which we can evaluate the life science research in the region. Secondly, it allows us to identify specific challenges and opportunities, compare them with our point of departure, such as specific areas of excellence and ongoing investments and initiatives. Thirdly, it helps to highlight and emphasize the potential for future regional collaboration and point to strategies and actions that can help catapult the Medicon Valley region from its current status as the strongest life science cluster in the Nordics, but only a second tier life science cluster globally, to a global first-tier life science cluster, which, based on world class excellence in selected areas, can credibly position itself as the leading life science cluster in Northern Europe.

Not surprisingly, the life science research is headed by the largest, broadest and most internationally reputed universities in Copenhagen and Lund, but both Malmö University and Roskilde University have created an interdisciplinary image for themselves. When it comes to engineering, the Technical University of Denmark (DTU) stands out in the region, and current investments aimed at strengthening DTU's profile within life science and bioengineering makes DTU a strong third, when it comes to the importance and impact of the universities for life science related R&D in the Medicon Valley region.

This analysis also specifically highlights the potential related to the synchrotron light facility MAX IV, inaugurated in June 2016 and the neutron research facility European Spallation Source (ESS) currently under construction and scheduled to open in 2023. These two truly world class research facilities can not only serve as global-ranging scientific beacons for the Medicon Valley region, but also to some extent improve the Danish-Swedish balance within Medicon Valley, ensure strengthened collaboration and provide an opportunity to promote the life science cluster of the Greater Copenhagen region more consistently and effectively.

I hope you will enjoy the reading.

Copenhagen and Malmö 17th of August, 2017

**Petter Hartman** *CEO Medicon Valley Alliance* 





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**SUMMARY** 

**70000** There are nearly 7 000 life science researchers working at universities in the Medicon Valley area – from over 4 000 at the University of Copenhagen to around 30 at Kristianstad University. Still others work at hospitals and other research institutions.

# **Bigger is better**

The University of Copenhagen, followed by Lund University and DTU, generally places highest in the region on the most prestigious of the international ranking lists. But the specialised area at the Swedish University of Agricultural Sciences is also prominent.





Metabolic diseases such as diabetes and cancer, and stem cells and neuroscience are some of the region's largest and most successful medical research areas. In a broad definition of life science, there is also a significant amount of research in bio-engineering, biorefinery and bio-based raw materials.

**2483** international researchers worked in Denmark in 2015, according to how many used the country's tax relief scheme.

Personalised medicine is a strong trend in life science research – not only in Medicon Valley. Carl Borrebaeck, Professor of Immunotechnology at Lund University, helped develop a test that is expected to save the lives of many patients with pancreatic cancer.

# Collaboration contract to give a double view of research

The research facilities ESS and MAX IV signed a contract in May that aims to create scientific collaboration in materials and life science, exploiting complementarity between X-rays (MAX IV) and neutrons (ESS). In addition, they plan to collaborate on practical issues such as how to build and maintain a large research facility and host guest researchers from all over the world. 9

that's how many universities in Medicon Valley perform life science research. Five of them are in Denmark, and four are in Sweden.

# GREAT EXPECTATIONS FOR NEW RESEARCH FACILITIES

Around 7 000 researchers at nine learning institutions in Medicon Valley conduct life science research: the University of Copenhagen, Lund University, the Technical University of Denmark, the Swedish University of Agricultural Sciences (SLU) in Alnarp, Malmö University, the National Institute of Public Health/SDU, Roskilde University, Kristianstad University and Aalborg University in Copenhagen. Important research areas in the region are diabetes and metabolic diseases, cancer, neuroscience and stem cell research, biobased applications and biorefinery, plant science and protein research. Some of the many thriving, but less broad, areas of research are genomics and metagenomics, coagulation, sports medicine, chemical ecology and biobarriers.

From an international perspective, Medicon Valley is just a notch below the most successful life science regions, but more specialised and strong niche areas create potential for the region's universities to become prominent in the global competition for researchers and funding. These niche areas may comprise certain research areas – as the elite research centres at the University of Copenhagen – or an entire university, as in the Swedish University of Agricultural Science in Alnarp.

All the while, expectations are mounting when it comes to the opportunities and potential that the research facilities ESS and MAX IV will bring to life science research.

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# and research in biorefinery, biofuel and bio-based raw materials.

• There are nine universities that conduct research in the life sciences in Medicon Valley: the University of Copenhagen, Lund University, the Technical University of Denmark (DTU), the Swedish University of Agricultural Sciences (SLU) in Alnarp, Malmö University, Roskilde University, Kristianstad University, Aalborg University in Copenhagen and the University of Southern Denmark, which runs the National Institute of Public Health in Copenhagen.

 These universities range from long-established and multifaceted universities with subject-oriented departments to newer universities and institutions that emphasise interdisciplinarity.

There are around 7 000 university researchers conducting research in the life sciences at nine universities in the Medicon Valley area. Meaningful and internationally respected research is being done within the fields of medicine, science and engineering, with examples such as neuroscience, diabetes and cancer research

- The most comprehensive and outstanding research in the region concerns diabetes and metabolic diseases, neuroscience, stem cells, and cancer. Other important areas are e.g. genomics and metagenomics, and regenerative medicine.
- Biorefinery, biofuels and biomass are a research area at a number of learning institutions, including Lund University, the Swedish University of Agricultural Sciences in Alnarp, Roskilde University and Aalborg University in Copenhagen.
- There is also comprehensive research in the life sciences at the regional hospitals and at institutions and organisations such as the State Serum Institute and the Danish Cancer Society.

# DIABETES, NEUROSCIENCE AND CANCER RESEARCH PREDOMINATE

Life science research is performed at nine learning institutions in the Medicon Valley area, but two of the largest universities dominate clearly: the University of Copenhagen and Lund University with more than 4 000 and about 1 300 researchers (figures incomplete) in the life sciences, respectively. The most comprehensive and outstanding research in the region concerns diabetes and metabolic diseases, neuroscience, stem cells, and cancer.

There is an obvious connection between the largest pharmaceutical companies in the region and the largest research districts at the universities and learning institutions. Diabetes and metabolic diseases and neuroscience are Novo Nordisk and Lundbeck's areas, respectively; with their foundations, both of them also contribute to research funding in the region.

Stem cell and cancer research are also strong areas that can be found at both of the large universities. The University of Copenhagen performs world-class research in for example genomics and metagenomics, whilst Lund University is currently building up a large research centre with young researchers of regenerative medicine, with support from the Wallenberg Foundation.

But life science research in the region is not limited to medicine. Biorefinery, biofuels and biomass are a research area at a number of learning institutions, including Lund University, the Swedish University of Agricultural Sciences in Alnarp, Malmö University, Roskilde University and Aalborg University in Copenhagen.

Following the University of Copenhagen and Lund University in descending size order comes the Technical University of Denmark (DTU), with more

# 9 UNIVERSITIES AND 7 000 RESEARCHERS A broad research perspective



Steno Diabetes Center Copenhagen wants to be a globally leading institution for the treatment and research of diabetes. The Capital Region of Denmark overtook the centre from Novo Nord-

isk on Jan 1, 2017 after a donation of one billion Danish crowns from the Novo Nordisk Foundation. The money will be used to build a new diabetes centre at Herlev Hospital, and more.

# ADDITIONAL RESEARCH AT HOSPITALS AND INSTITUTIONS

Life science research is not only conducted at the region's universities on which we have chosen to focus in this analysis. There is also comprehensive research in the life sciences at the regional hospitals, as well as at institutions and organisations such as the State Serum Institute and the Danish Cancer Society. Furthermore, many of the region's life science companies conduct research with a commercial focus.

Research in the life sciences is an important part of activities at the hospitals of the Capital Region of Denmark, and Region Zealand and Region Skåne, not least at the university hospital Rigshospitalet, Sjællands Universitetshospital (Zealand), and the Skåne University Hospital. According to the regions themselves, the Capital Region of Denmark has around 4 000 active researchers, Region Zealand about 500 and Region Skåne 1100-1200 (at Skåne University Hospital – the total number of researchers in the region is around 1 500). Research is conducted both independently and in collaboration with the region's universities, and there is thus a significant overlap in the number of researchers at hospitals and universities.

Some of the strong areas in the Capital Region of Denmark are reproductive biology, medicine general and internal, obstetrics and gynaecology, as well as biotechnology and applied microbiology. The subject areas with the largest number of scientific articles in the region in 2015 were oncology, cardiac and cardiovascular systems, endocrinology and metabolism. The corresponding areas in Region Zealand are surgery, dermatovenerology, psychiatry, and obstetrics and gynaecology.

Strong research areas at the Skåne University

Hospital and in Region Skåne are cancer, neurodegenerative disorders, cardiology, stroke, musculoskeletal disorders, transfusion medicine and haematology, genetics, diabetes, nursing care and primary care. Further, the Skåne University Hospital combines national tertiary care and European tertiary care with leading research in childhood oncology, childrens surgery, heart and lung transplantation.

> The State Serum Institute is in Copenhagen and belongs to the Danish Ministry of Health, whose main duty is to ensure preparedness against infectious diseases and biological threats and intervention in the event of congenital diseases. The institute's research focuses on e.g. ensuring preparedness using various methods, the study of biobank material and health register data with the correlation of genetics, immunology, biomedicine and epidemiology and vaccine research to gain understanding about methods and side effects. A total of 225 researchers (173.5 if calculated as full-time positions) work at the State Serum Institute.

> The Danish Cancer Society is a disease-fighting and patient organisation whose aim is to fight cancer and its side effects through research, information and patient support. There are 136 researchers working at the Danish Cancer Society Research Center (DCRC) in Copenhagen. Two are them receive funding via the University of Copenhagen, and the remainder are financed by the Danish Cancer Society or unaffiliated research resources.

Life science research is also conducted on a small-scale at the Copenhagen School of Design and Technology, where there is one researcher in optometry.

than 700 researchers in the life sciences. Bioinformatics, protein chemistry and so-called cell factories are important subject areas for research.

The Swedish University of Agricultural Sciences in Alnarp, Malmö University, Roskilde University, The National Institute of Public Health - run by the University of Southern Denmark, Aalborg University in Copenhagen and Kristianstad University all perform research on a smaller scale within life science, with between 221 and 24 researchers each in the area.

Collaboration between the universities and learning institutions is widespread in the region; while it is primarily on the national level, there is also a certain degree of transnational collaboration. The University of Copenhagen collaborates with Lund University on coagulation, transplants and neuroscience, for example, but it also collaborates on a smaller scale with Malmö University. Proponents of research would like to see increased collaboration between Sweden and Denmark and have called for more contact points and easier conditions for commuting.

Collaborations with the business sector include small and large companies, and often depend on geography and research areas. A number of the smaller learning institutions focus on applied research and collaboration with the business sector rather

than basic research, which is primarily performed at the University of Copenhagen and Lund University. However, due to the sheer size of the latter two, they still retain the majority when it comes to collaborations with businesses.

All of the region's universities and learning institutions emphasise the importance of involving students in research, not least when they are doing their thesis work. Some of the smaller learning institutions - Roskilde University, Aalborg University in Copenhagen and the Swedish University of Agricultural Sciences in Alnarp – further emphasise this by integrating project-based work early in their programmes, which means that students quickly take their first steps in the research world.

This analysis concentrates primarily on life science research at universities and colleges in the region, which is also reflected in the following chapter. However, in addition to the research performed at the nine learning institutions detailed here, life science research is also undertaken at the region's hospitals and at institutions and organisations such as e.g. the State Serum Institute (SSI) and the Danish Cancer Society. Research is also performed within life science companies.

# RESEARCHERS AND STUDENTS IN LIFE SCIENCE

	Univer- sity of Copenha- gen	Lund Univer- sity	Technical Univer- sity of Denmark	Swedish University of Agri- cultural Sciences in Alnarp	Malmö Univer- sity	National Institute of Public Health – University of Southern Denmark	Roskilde Univer- sity	Kristi- anstad University	Aalborg Univer- sity in Copen- hagen
Total number of researchers*	4 243	1 271**	736	221	98	67	55	30	24
Number of professors	519	217**	55	28	20	8	6	6	4
Number of PhD students	2 031	1069**	238	25	25	12	19	7	6
Number of students	12 697	Circa 2 800**	2 283	635	Circa 2 000	0	459	n.a.	n.a.

\*Includes professors, associate professors, lecturers, post docs, doctoral students, etc.

\*\*The figures are only for the Faculty of Medicine at Lund University. The university did not submit data from the Faculties of Science and Engineering.

University of Copenhagen: Professors in FTE/full-time positions. Doctoral students and total number of researchers: full-time positions/head count.

Lund University: Of the doctoral students, 316 are employed by Lund University; thus, only this number is included in the total number of life science researchers. The remainder

are part-time doctoral students employed by Region Skåne. Technical University of Denmark: 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. Swedish University of Agricultural Sciences in Alnarp: Includes student from the following programmes: Euroforester, Agroecology, Horticultural Science, Landscape Design, Agricultural Technology and Outdoor Environments for Health and Well-being. Malmö University: Year-round students.

# **BROAD FOCUS AT THE REGION'S UNIVERSITIES**



### 1. UNIVERSITY OF COPENHAGEN

Total number of employees: 9 763 of which researchers: 5 644 Total number of students: 38 615



#### 2. TECHNICAL UNIVERSITY OF DENMARK (DTU) Total number of employees: 5 896 of which researchers: 3 333

of which researchers: 3 333 Total number of students: 11 031



#### 3. ROSKILDE UNIVERSITY Total number of employees: 934 of which researchers: 568 Total number of students: 8 193



### 4. AALBORG UNIVERSITY IN COPENHAGEN

Total number of employees at AAU: 3 351 (of whom in Cph: 530) of which researchers: 2 012 Total number of students at AAU: 20 743 (of whom in Cph: 3 300)



5. THE NATIONAL INSTITUTE OF PUBLIC HEALTH (NIPH), UNIVER-SITY OF SOUTHERN DENMARK Total number of employees at NIPH: 130 of which researchers: 67 Total number of students: 0

Life science research is performed at nine universities in the Medicon Valley area. These nine differ in many ways, e.g. their size, their areas of concentration and their traditions. They range from long-established and multifaceted universities with subject-oriented departments to newer universities and institutions that emphasise interdisciplinarity.



4. MALMÖ UNIVERSITY Total number of employees: 1 343 of which researchers: 737 Total number of students: 14 600

When it comes to academic focus, the University of Copenhagen and Lund University are both largest and broadest, oldest and most internationally reputed. Two of the eight institutions that perform life science research have a particular focus: engineering at DTU and agriculture and landscape at SLU in Alnarp.

Roskilde University and Malmö University have both created an interdisciplinary image for themselves. Malmö University and Kristianstad University are technically colleges, with significantly greater focus on education than research, but after a decision by the Swedish government, Malmö will gain official university status as of 2018.

Two of the universities are branches of universities in other places: Aalborg University in Copenhagen, whose



#### 1. KRISTIANSTAD UNIVERSITY Total number of employees: 469 of which researchers: 301 Total number of students: 8 058



#### 2. LUND UNIVERSITY Total number of employees: 6 879 of which researchers: 2 961 Total number of students: 29 595

Source: Universities Denmark, numbers for 2016, Swedish Higher Education Authority, numbers for 2016 (autumn)

main university is in Aalborg, and the Swedish University of Agricultural Sciences, which has branches in Alnarp, Uppsala and Umeå. The National Institute of Public Health used to belong to the Danish state, but is now run by the University of Southern Denmark.

Total number of employees: 2 855 (of

Total number of students: 4 466 (of

whom in Alnarp: 400)

whom in Alnarp: 1 200)

of which researchers: 1 362

In addition to these learning institutions with life science research, there are a number of other institutions for higher learning in the region – such as Copenhagen Business School, the IT University of Copenhagen and various art academies. Furthermore, the Copenhagen School of Design and Technology has branches in Copenhagen and in Zealand. The former has some life science research, but on such a small scale – one researcher – that we have chosen to omit the school from this compilation.

# UNIVERSITY OF COPENHAGEN (UCPH)



The University of Copenhagen is the largest learning institution in the region – not only in general, but also for life science, employing more than 4 000 researchers in the Medicon Valley area. Ac-

cording to the university, the important and strong areas where they perform world-class research include metabolic diseases such as diabetes, cancer research, and genomics and metagenomics.

Life science research at the University of Copenhagen is performed at the Faculty of Health and Medical Sciences and the Faculty of Science, both of which comprise numerous departments and research centres.

At the Faculty of Health and Medical Sciences, comprehensive and traditionally strong metabolic research, particularly in diabetes, is being done at e.g. the Center for Basic Metabolic Research. Cancer research at the faculty is outstanding, not least at the elite centre for biomedical research, Biotech Research & Innovation Centre (BRIC). Neuroscience research, particularly in diseases such as dementia, Alzheimer's and Parkinson's, has grown stronger and according to the faculty's Vice Dean for Research Kristian Helin, research there now matches the class of the activity on the other side of the Øresund, where it has long since flourished.

He also mentions the research being done on cell growth and the role that proteins play in it – which can be used to develop new pharmaceuticals –at the Novo Nordisk Foundation Center for Protein Research (located within the faculty) as world-class research.

Research on chromatin and DNA damage being performed at e.g. the Center for Chromosome Stability is also spotlighted as a beacon area.

In addition, public health sciences in register research and epidemiological research are strong areas from an international perspective. The same goes for the rest of Denmark and Sweden; the opportunities for research are favourable here in light of the fact that there are public health registers from quite a long time ago.

While pharmacy research here is less comprehensive, it has been successful in terms of developing new kinds of pharmaceuticals, says Kristian Helin. He also points to veterinary medicine, food research and research on infectious diseases, in virology as well as bacteriology.

- While not everything is world-class, we have many strong environments, and we work hard to bring everything to the highest possible standard, he says.

Which research areas have been most successful is

in part a question of the faculty's strategic investments over the past ten years, combined with the influence of large Danish foundations with research funding. The Novo Nordisk Foundation has supported metabolic research, for example, whilst Lundbeckfonden has been active in for example neuroscience.

According to Kristian Helin, another relevant point is which areas have been traditionally strong; metabolism is once again an example. An additional factor that can build up a new strong research area somewhat haphazardly is the university's ability to bring in young talents, for example those who have received larger junior researcher grants from the Novo Nordisk Foundation, Lundbeckfond, or the EU's ERC.

- We try to encourage everyone in the faculty to bring in people who can receive grants like those, since that means that they are at the forefront internationally with their research. We put efforts into what has been strong traditionally, but also more momentarily arising areas. If one only supports research that is established and strong, there is a risk of not catching hold of the talents one needs in that area. There is also a need for those who perform a new kind of research, says Kristian Helin.

A large part, but not all of the research at the Faculty of Science falls into the category of life science. Some of the strongest life science research at the faculty is in genomics and metagenomics, plant science and bioinformatics, the standard of which is world-class, according to the university. A research centre in genomics is run in collaboration with the Chinese Beijing Genomics Institute. DTU and Aarhus University also participate in the project.

Research at the basic research centre BASP – the Center for Bacterial Stress Response and Persistence – is also thriving according to Michael Lisby, Vice Head of the Department of Biology, where the centre is located. At the centre, research is performed on microbial resistance and the relationship between micro-organisms and antibiotics. Research is also strong

Morten Pejrup believes that ESS, MAX IV and the X-ray laser facility European XFEL in Hamburg will influence the type of research undertaken at the

funding, says Vice Dean of Research Kristian Helin.

in e.g. structural biology, where the faculty is involved

tage of the material research facilities ESS and MAX

The two centres at the Faculty of Science that

Molecular Interactions (DynaMO) and Copenhagen

Plant Science Center – have received beacon funding

The faculty also highlights the stem cell research

An additional area that has been performing

muscle physiology and work physiology, according to the Vice Head of the Department of Nutrition,

research of the highest standard for a long time is

Exercise and Sports Jens Bangsbo. The research

between the Faculty of Science and the Faculty

quality is consistently high.

being done at the department can be classified as

of Health and Medical Sciences, and the research

- We collaborate extensively with researchers

and there have been discussions about whether that

tage of the current location is that we can maintain

from the Faculty of Health and Medical Sciences

faculty would be a better location, but the advan-

closer contact with the more traditional scientific

The Faculty of Science works mainly with en-

couraging transdisciplinary collaborations, which has

brought about more successful research when it comes

to modelling biological systems, where physics resear-

tions made in epigenetics by biology researchers.

iting researchers from abroad, which has further reinforced research, according to Vice Dean of

Research Morten Pejrup. A phenomenon at the

University of Copenhagen, as well as at other uni-

versities and learning institutions in the region, is

around strong individual researchers.

that thriving research environments often converge

The Faculty of Health and Medical Sciences is also

working with researcher recruitment within e.g.

bigger and more important in the future.

stem cell research, an area expected to grown still

- We are aiming to recruit really excellent resear-

chers who can bring in national and international

chers created models of some of the biological observa-

The faculty has also focused its efforts on recru-

departments and dovetail their science with the

medical research, Jens Bangsbo says.

concern plant research – the Center for Dynamic

IV that are currently being established in Lund.

and attracted outstanding young researchers.

at the Center for Stem Cell Decision Making.

in initiating projects and activities that will take advan-

university in the future. The Faculty of Science is encouraging all of the biological environments to make use of the new technologies, and the expectations of what results that might produce are high The faculty is also investing in research that uses NMR-technology (nuclear magnetic resonance).

### External collaborations

As the region's largest learning institution, the University of Copenhagen has a great many external collaborations. For example, life science researchers collaborate with Danish hospitals such as Rigshospitalet, Glostrup Hospital and Herlev Hospital. Certain parts of the collaboration between the Faculty of Science and the Capital Region of Denmark were recently formalised in the forum Copenhagen Health Science Partners, which was modelled on Kings College in London. The plan is to select collaborative groups comprising clinics and researchers, who will then receive research funding with the overarching goal of bringing university research to patients more quickly.

Individual researchers and research groups collaborate extensively with other universities in Denmark and abroad. One example is the Chinese Beijing Genomics Institute mentioned earlier.

On a broader level, the University of Copenhagen is a member of IARU, International Alliance of Research Universities, and LERU, League of European Research Universities. IARU is a high profile international collaboration with just eleven members, the best known of which are the University of Oxford, University of Cambridge, University of California/ Berkeley and Yale University. Among other things, it entails an exchange for university employees. The European university consortium LERU has 23 members – one of which is Lund University – and it strives to promote basic research and influence research and teaching policy in Europe.

Life science researchers at the University of Copenhagen also collaborate extensively with small and large businesses in the region. Novo Nordisk, Lundbeck, Novozymes, Christian Hansen and Carlsberg are some of the larger joint ventures emphasised, but there are also collaborations with small and medium-sized companies. Collaboration with the business sector is also rewarded when applying for funding from Innovation Fund in Denmark, for example, but also from private foundations like the Novo Nordisk Foundation and Lundbeckfond. They can also fund spin-off companies that have emerged from the research done at the university.

# THE UNIVERSITY OF COPENHAGEN

Total number of life science researchers: 4 243 (full-time employees/head count for doctoral students) - of which professors: 519 full-time (including 197 clinical professors) - doctoral students: 2 031 (full-time/head count)

#### Total number of students in life sciences: 12 697

#### Life science research is performed at the Faculty of Health and Medical Sciences at the following departments:

Department of Biomedical Sciences Department of Cellular and Molecular Medicine Department of Immunology and Microbiology Department of Forensic Medicine Department of Public Health Department of Odontology Department of Clinical Medicine Department of Pharmacy Department of Drug Design and Pharmacology Department of Veterinary Clinical Sciences Department of Veterinary and Animal Sciences

# and at the Faculty of Science at the following departments:

Department of Biology Department of Chemistry Department of Food and Resource Economics Department of Food Science Department of Geosciences and Natural Resource Management Department of Nutrition, Exercise and Sports Department of Plant and Environmental Sciences Natural History Museum of Denmark Niels Bohr Institute

# Additionally, at the following centres at the Faculty of Health and Medical Sciences:

Novo Nordisk Foundation Centres: The Novo Nordisk Foundation Center for Protein Research (CPR) The Novo Nordisk Foundation Center for Basic Metabolic Research (CBMR) Danish Stem Cell Center (DanStem) (co-founded: Danish Council for Strategic Research)

#### **Biotech Research and Innovation:**

BRIC – Biotech Research and Innovation Centre

#### Neuroscience Research Centre: Center for Neuroscience (CNS)

Centers of Excellence (by the Danish National Research Foundation (DNRF):

Copenhagen Center for Glycomics (CCG) Center for Chromosome Stability (CCS) Danish Arrhythmia Centre (DARC) Centre of Inflammation and Metabolism (CIM) Center for Epigenetics

#### Lundbeck Foundation Centres:

Lundbeck Foundation Research Initiative on Brain Barriers and Drug Delivery (RIBBDD) The Lundbeck Center for Neurovascular Signalling (LUCENS) The Lundbeck Foundation Center for Integrated Molecular Brain Imaging (CIMBI) Copenhagen Studies on Asthma in Childhood (COP-SAC)

Nordea-fonden Centre:

The Center for Healthy Ageing (CEHA)

#### Other centres (within departments):

Centre for Medical Parasitology (CMP) Copenhagen Centre for Regulatory Science (CORS) Copenhagen Center for Disaster Research (COPE) Center for non-coding RNA in Technology and Health (RTH)

Centre for Health Economics and Policy (CHEP) University of Copenhagen Research Centre for Control of Antibiotic Resistance (UC-care) Center for Biopharmaceuticals Costerton Biofilm Center (CBC) Copenhagen Hepatitis C Program (CO-HEP) Danish Obesity Research Centre (DanORC) Novo Nordisk - LIFE In Vivo Pharmacology Centre (LIFEPHARM) Center for Research in Pig Production and Health (CPH Pig) Center for Research in Mink Production, Health and Welfare (CPH Mink) Center for Research in Cattle Production and Health

(CPH Cattle) LEO Foundation Center for Cutaneous Drug Delivery

Sino Danish Breast Cancer Research Center

# LUND UNIVERSITY

Research in neuroscience, diabetes and stem cells are among the areas with the most outstanding research in the life sciences at Lund University, ranging from European top class to absolute world-class. With funding from the Knut and Alice Wallenberg Foundation, the university is now also investing big in a new research centre for regenerative medicine.



The largest research areas at the Faculty of Medicine are neuroscience, diabetes and stem cell research, followed by cancer. Structural work is currently underway in the latter area in order to more effectively consolidate the research being done.

Another outstanding area – albeit with a smaller group of researchers – is coagulation; Lund University maintains a comprehensive collaborative relationship with the University of Copenhagen in the area. Transplantation is yet another strong area at Lund University and Skåne University Hospital, which is one of the two hospitals in Sweden that performs lung and heart transplants.

Cardiology is another area of excellence, as is the research being done on Huntington's Disease, according to Gunilla Westergren-Thorsson, Dean of the Faculty of Medicine at Lund University.

Stem cell research at Lund University has long since been successful, concerning for example the building of scar tissue and the optimal tissue environment for stem cells. The research environment StemTherapy, run by Lund University and Uppsala University, has for example been named a national strategic research area.

Neuroscience also has a long history at the university, where transplants were already being tested in the 1980s. Neuroscience remains a field of research in which the university is quite advanced, and the next step for researchers in Lund will be to initiate cell therapy tests with Parkinson's patients.

Both of the latter areas – and many others – are part of the large investment being made at the Wallenberg Centre for Molecular Medicine at Lund University, which is being financed with 535 million Swedish crowns from the Knut and Alice Wallenberg Foundation, Lund University and Region Skåne. The centre is part of a national investment in universities in Gothenburg, Umeå and Linköping and the SciLifeLab in the Stockholm-Uppsala Region made by the Wallenberg Foundation. One aim is for researchers to forge a strong and lasting collaborative relationship.

The centre's overall focus is on regenerative medicine, and the plan is to recruit young researchers who will create their own research groups; this task is already underway.

One of the centre's areas of concentration will be structural biology, and the research facility MAX IV will be of importance.

- We will be able to work in a different way on many things with ESS and MAX IV; we will be able to take advantage of each other's competence and build with a greater perspective, says Gunilla Westergren-Thorsson.

She highlights one area as increasingly important in medical research: personalised medicine – where a personalised treatment is created for each individual patient. At Lund University, this type of research is supported by e.g. strong technical platforms such as the research centre Centre of Excellence in Biological and Medical Mass Spectrometry, which is run collaboratively by the Faculties of Medicine and Science and the Faculty of Engineering, and Lund Protein Production Platform (LP3), which is part of the Department of Biology at the Faculty of Science.

Other areas that are gaining significance at Lund University are e.g. orthopaedics, sport injuries, blood and diseases of the blood. Health science is also growing strong, according to Gunilla Westergren-Thorsson.

- It's about measuring: "Am I training right?" In the future we won't be able to afford to treat every illness; instead, we will have to use other instruments: training, eating right and stressing less, she says.

An important research area related to life science at the Faculty of Science concerns animal super senses, from dung beetles to seabirds – for example colour- and scotopic vision, nasal form and pheromones. Biology research at the faculty also includes



how molecular techniques can be used to respond to evolutionary and ecological questions, studies of how copies of old genes can give rise to new genes, and how "suicide genes" can be used in cancer therapy, as well as research of so-called gram-positive bacteria.

The climate research performed at the faculty also overlaps with life science to a degree, e.g. when it comes to questions of biodiversity and microbiological studies.

Research at the Department of Chemistry includes e.g. the production of biofuel from agricultural waste; molecular biology; studies of how plants, fungi and other organisms produce so-called secondary metabolites and how these can be used for pharmaceuticals; and research of proteins' physical properties, patterns of movement and interaction with other molecules, which is important for biomedical and biotechnical applications.

Life science research is also performed in several areas at the Faculty of Engineering (LTH), comprising e.g. cancer and allergy research (read more on page 38), medical signal processing and biomechanics, done in close collaboration with Skåne University Hospital.

Food research at the Faculty of Engineering con-

cerns e.g. nutritional science, the composition of food and the qualities of food in relation to consumer health.

#### External collaborations

Researchers at Lund University collaborate with many universities and higher learning institutions in Sweden and abroad. The University of Copenhagen is an important collaborative partner, e.g. in the areas coagulation, transplants and neuroscience.

Collaborative work in the context of the research centre Wallenberg Centre for Molecular Medicine at Lund University is also planned; partners will include the University of Copenhagen and other Danish universities. As mentioned earlier, the centre will also work with universities in Gothenburg, Umeå and Linköping, as well as SciLifeLab.

Lund University also works with the industrial sector – particularly in Denmark when it comes to the life sciences; Gunilla Westergren-Thorsson mentions e.g. a collaboration on diabetes research with Novo Nordisk. She expects that both academic and industrial collaboration with Denmark will reach unprecedented levels when the research facilities ESS and MAX IV are fully operational. MAX IV itself is also part of the Faculty of Science at Lund University.

# LUND UNIVERSITY

**Total number of life science researchers:** 1 271\* – *of which professors:* 217\*

- *doctoral students:* 1 069 (of the doctoral students, 316 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.)\*

Total number of students in life sciences: About 2 800\*

\*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.

Life science research is performed at the Faculty of Medicine at the following departments: Department of Experimental Medical Science

Department of Health Sciences Department of Clinical Sciences, Malmö Department of Laboratory Medicine, Lund Department of Translational Medicine And at the Faculty of Science, at the following departments and centres: Department of Medical Radiation Physics Department of Biology Centre for Environmental and Climate Research

(CEC) Department of Physical Geography and Ecosystem Science

Department of Chemistry (also at the Faculty of Engineering)

As well as at the Faculty of Engineering, at the following departments: Department of Biomedical Engineering

Immunotechnology Department of Chemistry (also at the Faculty of Science) Chemical Engineering Food Technology, Engineering and Nutrition

Additionally, at the following centres that researchers from the Faculty of Medicine head or participate in: EpiHealth (Epidemiology) EXODIAB (Diabetes) Continues on the next page.. MultiPark (Neuroscience) Stem Therapy (Stem cell and regenerative medicinel BioCARE (Cancer) The Nanometer Structure Consortium (Nanoscience and nanotechnology) Lund University Diabetes Center - LUDC Neuronanoscience Research Center - NRC Hemato-Linné Centre for Economic Demography Bagadilico Thinking in Time: Cognition, Communication and Learning (CCL) Lund Laser Centre - LLC, incl. Medical Laser Centre Centrum for Aging and Supportive Environments: CASE Centre for Medicine and Technology for Working Life and Society: METALUND

Clinical Health Promotion Centre - WHO Collaborating Centre for Implementation of Evidence-based Clinical Health Promotion at Lund University in collaboration with Region Skåne Institute for Palliative Care – a joint venture of Lund University and Region Skåne Centre for Biomechanics at Lund University (CBML) Centre for Evidence-based Psychosocial Interventions (CEPI) - national knowledge centre Centre for Cardiac Arrest at Lund University Centre for Primary Health Care Research (CPF) - a joint venture of Lund University and Region Skåne Research School in Pharmaceutical Science (FLÄK) HAREC – Disability and Rehabilitation Research Centre Lund University Bioimaging Center

Lund University Bioimaging Center LOAD – joint competence in osteoarthritis research Malmö Cancer Centre (MCC)

# UNIVERSITY OF SOUTHERN DENMARK – THE NATIONAL INSTITUTE OF PUBLIC HEALTH



The National Institute of Public Health has been part of the University of Southern Denmark since 2007, but its premises

are still in Copenhagen. The research conducted there still concerns public health, but the focus is on e.g. large-scale surveys of the population and the population's health status. The institute, which used to be state-run and still has certain national obligations, does not have students of its own.

Research at the National Institute of Public Health concerns e.g. 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 and alcohol. The large surveys of the population and research on the population's health status concern diseases, mortality, risk factors, disease consequences, health-related quality of life, health behaviour, function level, living conditions and environmental impact.

In the future, there will be particular focus on the institute's research on smoking, alcohol, intervention research, physical activity, mental health, chronic diseases and health inequality.

#### **External collaborations**

The National Institute of Public Health has the speci-

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al task of supporting authorities with e.g. research-based advice. The institute also works with research and surveillance on behalf of patient organisations, municipalities, regions, unions and businesses.

# THE NATIONAL INSTITUTE OF PUBLIC HEALTH (NIPH)

Total number of researchers in life science: 67 - of which professors: 8 - doctoral students: 12 Total number of students in life science: 0

Life science research is performed at the whole institute.

# TECHNICAL UNIVERSITY OF DENMARK (DTU)



Cell factories and bio-manufacturing, protein chemistry and bio-informatics are some of the important research areas in the life sciences at DTU. The university has also invested in two large buildings

that will boost its laboratory capacity and bring together the departments in the surrounding area.

One of the buildings, of 12 500 m2, will house DTU Biosustain – Novo Nordisk Centre for Biosustainability. DTU has also invested in a new complex for life science and bioengineering at the Lyngby Campus, whose 47 000 m2 is the new site of DTU Aqua, DTU Food, and DTU Vet. The investments are right in line with the technical university's strategic goal to strengthen their research in life science and bioengineering.

One of the largest areas of life science research at DTU concerns the creation of so-called cell factories, which can be used to e.g. create new bioactive compounds, new antibiotics and pharmaceuticals, as well as for the development of new tools for cell design.

Bioinformatics is also a strong area of research according to the report "Dansk life science under mikroskop" (Danish Life Science under the Lens) from 2017 by Iris Group on behalf of DTU. In bioinformatics, large amounts of biological data and health-related patient data are compiled in order to identify possible correlations between patient types, genetics, treatment forms and diseases.

Another important research area concerns protein structures and chemical characteristics.

Other major research areas related to the life sciences include, according to the report, hearing technology, acoustics and audiology, fermentation, water engineering and fishery and aquaculture. Nanotechnology research, which is used to e.g. develop immunotherapies for cancer and techniques for encapsulating pharmaceuticals until they have arrived at the right location within the body, is said to be so successful that together with the Nano Science Centre at the University of Copenhagen, DTU Nanotech and DTU Mechanical Engineering comprise one of the world's five to ten strongest research environments in the field.

The calculation is based on the number of scientific articles and their citation frequency and it also reveals the following five strong positions: basic research in plant science, microbiology and biotechnology; research of certain diseases (cancer and hormonal diseases), which is also related to research in e.g. protein chemistry and bioinformatics; pharmacology; toxicology (e.g. toxins in food); and research in agronomics/crops/forestry.

#### **External collaborations**

The Technical University of Denmark collaborates extensively with businesses within life sciences; an example is the hearing aid manufacturer Oticon. Researchers at DTU also collaborate with various hospitals in the region, for example in bioinformatics. DTU Bioinformatics also runs the Danish National Supercomputer for Life Sciences and data centre Computerome, which is also used by other life science researchers in Denmark and abroad.

# THE SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES (SLU) IN ALNARP

Chemical ecology, plant breeding, biobased raw materials, and

biobased products and applications are among the major research areas at the Swedish University of Agricultural Sciences in Alnarp. A small team of chemical ecology researchers studying how odours can be used to affect vectors of e.g. malaria and dengue fever is considered to be among the world's top researchers.

The Swedish University of Agriculture Sciences has a number of locations in Sweden, and the campus in Alnarp is one of the three largest, employing ten per cent of the University's total number of employees. Originally, the institution in Alnarp aimed to educate students who would then develop agriculture in Sweden, and research there took off when researchers were recruited in the 1980s, particularly from Lund University.

-Alnarp was conceived as a research facility for agriculture and horticulture, and the research aspect was less weighty. But since our research has gotten strong, chemical ecology and plant breeding have become some of our main areas, says Eva Johansson, Vice Dean responsible for research at the Faculty of Landscape Architecture, Horticulture and Crop Production Science, located in Alnarp.

Landscape and horticulture remain two of the faculty's main focal areas, and the research within the former, which overlaps into life science, has excelled, says Eva Johansson.

As is the case at all learning institutions, tradition and recruitments have had an impact on which areas have grown strong, as well as which fields have gotten increased funding possibilities, as they are considered strategically important in Sweden and/or Europe. An example is research of biobased raw materials, biobased products and applications, where e.g. the use of plant proteins for biobased products is explored.

Applied research accounts for a significant portion of the research done at Alnarp, with particular focus on contemporary areas of application.

### **External collaborations**

The Swedish University of Agriculture Sciences in Alnarp has a long history of collaboration with the business sector in areas such as agriculture, horticulture, food, chemicals, medicine and material, and Eva Johansson describes the collaboration as uncommonly thorough. It is organised in part via Partnership Alnarp, a formal organisation that connects industry and research.

As far as academic research is concerned, the collaboration is predominantly with Lund University; it is geographically close, and according to Eva Johansson, research performed there often complements research being done at SLU. There are also collaborations with Malmö University, the Royal Institute of Technology (KTH), Uppsala University, Stockholm University and Kristianstad University, as well as the University of Copenhagen.

# THE SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES IN ALNARP

Total number of researchers in life science: 221

- of which professors: 28
- doctoral students: 25

Total number of students in life science: 635

Life science research is performed at the Faculty of Landscape Architecture, Horticulture and Crop Production Science at the following institutions: Department of Work Science, Business Economics and Environmental Psychology Department of Biosystems and Technology Department of Landscape Architecture, Planning and Management Department of Plant Breeding Department of Plant Protection Biology

and at the Faculty of Forest Science at the following institutions: Southern Swedish Forest Research Centre

# TECHNICAL UNIVERSITY OF DENMARK

Total number of life science researchers\*: 736 – of which professors: 55 – doctoral students: 238

Total number of students in life sciences: 2 283

# Life science research is performed primarily at the following departments:

DTU Aqua, DTU Bioengineering, DTU Bioinformatics, DTU Biosustain, DTU Food, DTU Vet

# Life science research is also performed at parts of the following departments:

DTU Chemical Engineering, DTU Chemistry, DTHU Compute, DTU Electrical Engineering, DTU Environment, DTU Mechanical Engineering, DTU Nanotech, DTU Nutech

\*The figures are based on a search of researchers from DTU Vet, DTU Food, DTU Aqua, DTU Bioengineering, DTU Bioinformatics and DTU Biosustain.



# MALMÖ UNIVERSITY

Life science research at Malmö University is concentrated largely around the research centre Biofilms – Research Center for Biointerfaces; according to Malmö University, the research centre is of the highest Scandinavian standard to world-class. The strongest

areas at the centre are Oral Biofilms at Interfaces, Biobarriers and Pharmaceutical Design, and Smart Materials at Interfaces.

Biofilms – Research Center for Biointerfaces is based in three faculties: Health and Society, Technology and Society, and the Faculty of Odontology, all of which have been teaching areas at Malmö University since its inception.

The area Smart Materials has numerous strong research strands, according to Acting Dean of the Faculty of Health and Society Thomas Arnebrant. Among them are implant research, performed at the Faculty of Odontology, and research concerning sensors and the development of methodology based on molecular imprinting – the latter with potential for application in cancer diagnostics – at the Faculty of Health and Society.

Within Biofilms, the university has had successful projects related to e.g. pharmaceutical preparations for topical use, in collaboration with a number of businesses and academic partners such as Linköping University, the University of Gothenburg and Lund University.

Malmö University has also received large grants from the Swedish Research Council in the two abovementioned areas for the preparation of biological system studies to be carried out at the materials research facilities ESS and MAX IV.

– We are at the forefront in the area with respect to our size, says Thomas Arnebrant.

Oral Biofilms was one of the original parts of the research centre and comprises research on biofilms in the oral cavity, caries, periodontitis and oral diseases. Thomas Arnebrant calls attention to the university's work in microbiology, where studies are being done on how bacteria behave on the biofilm level, how



they are affected by other co-existent micro-organisms, and the role that the environment plays.

Thomas Arnebrant reports that Biofilms – Research Center for Biointerfaces received very positive feedback in an evaluation in the autumn of 2016, and the publication volume was judged as good.

- However, we are underrepresented in the leading journals, which is in all probability a result of the research centre's predominant focus on applied research and collaboration with businesses than basic research.

In addition to the Biofilm centre, there is a specialised team for health equity, where researchers study e.g. the conditions for equity in health and the opportunities for access to equal healthcare in various contexts. Furthermore, there are opportunities to broaden e-health research at the centre Internet of Things and People.

While it is technically a college today, Malmö University will officially receive status as a full university in 2018, and its research budget will increase accordingly.

#### **External collaborations**

Life science researchers at Malmö University have long since collaborated closely with Lund and Linköping Universities, and efforts are also being made to establish collaborations with the University of Copenhagen and Chalmers in Gothenburg.

One of the most important areas for collaboration right now concerns the exploitation of ESS and MAX IV in the area of smart materials.

In the life sciences, Malmö University also works with 30 to 40 companies, large and small. Among these companies are for example the pharmaceutical companies Ferring and Galenica.

# MALMÖ UNIVERSITY

Total number of life science researchers: 98 - of which professors: 20 - doctoral students: 25 Total number of student in life sciences: About 2 000 year-round Life science research is performed primarily at the Biofilms – Research Center for Biointerfaces, comprising researchers from three faculties: Health and Society, Odontology, and Technology and Society.

# ROSKILDE UNIVERSITY (RUC)



Green chemistry and enzymes – studied in close collaboration with Novozymes – are among the strongest areas of life science research at Roskilde University, along with research in e.g. biological production, ecotoxicology, and biomedicine.

Research in the life sciences comprises a central, albeit small part of the total research at Roskilde University, where interdisciplinary collaborations are encouraged.

The largest life science research group at Roskilde University is in biomedicine, which has been part of the institution since the mid 1990s. The work being done at Roskilde University includes biomedical research (biology of cancer, pathogens, autoimmunity and lifestyle diseases); protein and peptide research (development and use of bioactive peptides and antifreeze proteins); and cell biology research (molecular mechanisms in DNA replication, gene regulation and signalling). Interdisciplinary collaboration with chemistry and mathematical modelling is a new and growing research area.

A small but outstanding group at the university researches antifreeze proteins.

Environment is one of the research areas typically associated with Roskilde University. One of the strongest life science research areas, green chemistry, strives to make new types of biofuel through the development of new enzyme systems. A large area within biological production and breeding is aquaculture, and research there concerns e.g. how to use water fleas to develop a new type of fish feed. Within ecotoxicology, research concerns sediment and soil and the transformation of chemicals and their effects on biology, relevant with for example nanoparticles.

The strongest area of research in the natural sciences at Roskilde University concerns soft and amorphous systems and comprises the basic research centre Glass and Time; however, the research is located at the outermost edge of the category life science.

### External collaborations

Life science researchers at Roskilde University collaborate with large and small businesses, including pharmaceutical companies. There are also significant collaborations with hospitals in the region. The majority of the research projects at the university are undertaken in collaboration with other actors; i.e. either other learning institutions or businesses.

# **ROSKILDE UNIVERSITY**

**Total number of life science researchers:** 55 – of which professors: 6

- doctoral students: 19
- Total number of students in life sciences: 459

Life science research is performed at the Department for Science and Environment. Research groups at the department are: Eukaryotic Cell Biology (Medical & Molecular Biology Section) Molecules and General Physiology (Medical & Molecular Biology Section) Functional Biomaterials (Chemistry Section) Environmental Dynamics (Environmental Dynamics Section)



# **KRISTIANSTAD UNIVERSITY**

Life science research at Kristianstad University focuses primarily on four areas: Health Science, Biomedicine, Food and Meal Science, and Environmental Science in the research environment Man & Biosphere Health, which concentrates on biological, chemical,

biomedical and transdisciplinary research. Health science is the university's largest area of research, and environmental science has been successful at attracting funding.

The research platform for Collaboration for Health is Kristianstad University's largest research environment, where new research results are implemented in collaboration with Region Skåne and municipalities near Kristianstad. There are several research environments in health science, for example Man - Health – Society, which is one of Kristianstad University's prioritised areas.

The research carried out at Man & Biosphere Health concerns how humans impact ecosystems, as well as human beings' effects on biodiversity and health. Another relatively young and steadily growing research environment is Food & Meals in Everyday Life (MEAL), which focuses on the three areas Food Science, Nutrition and Health, as well as Food Culture and Communication. At the university, life science research is also performed as Herora Kets Takes To UNIVERSITA

part of the dental hygiene programme, and some pedagogical research relates to life science.

### External collaborations

Kristianstad University collaborates with local partners such as Kristianstad Municipality and the research park Krinova, as well as with other seats of learning such as Lund University and the University of Copenhagen.

– As a small university, we need to collaborate a lot. We work a lot with companies and we are quite advanced within food, says Karin Wendin, who heads the research group MEAL.

She mentions Culinar, Pernod Ricard, Findus and Orkla as examples.

Kristianstad University has also participated in international collaborations, for example through Interreg-projects.

# KRISTIANSTAD UNIVERSITY

Total number of life science researchers: 75 - of which professors: 18 - doctoral students: 9 Total number of students in life sciences: n.a.

Life science research is performed primarily at: The research environments Collaboration for Health, Man – Health – Society, Oral Health & General health & Quality

of life, Bio medicine, Man &

Biosphere Health and Food & Meals in Everyday Life (MEAL)



# AALBORG UNIVERSITY IN COPENHAGEN

There are two research groups at Aalborg University's campus in Copenhagen performing research in the life sciences: The Section for Sustainable Biotechnology (part of the Department

of Chemistry and Bioscience), whose primary focus is on biorefinery, and the group Center for RNA Medicine at the Department of Clinical Medicine, which researches non-coding RNA and RNA medicine in relation to cancer.

The research group at the Department of Clinical Medicine performing research in non-coding RNA and RNA medicine, called the Center for RNA Medicine, aims at developing new RNA-based therapeutics for the treatment of cancer and other life-threatening diseases. The group works translationally and focuses on innovation, according to its director Sakari Kauppinen. That makes it unique in Denmark in non-coding RNA and RNA therapeutics, says Sakari Kauppinen, who expects the size of the research group to double by next year.

The Section for Sustainable Biotechnology researches numerous aspects of biorefinery, founded on the notion that the plant should be used in its entirety for environmental as well as economic reasons. Among other things, the researchers study micro-organisms such as bacteria and fungi and test their potential to break down biobased raw materials into sugar or produce enzymes. Other areas of research include fermentation technology and membrane technology, developed at the section.

According to the Head of Section Peter Stephensen Lübeck, the group is strong in proteins, where they receive many requests for collaboration. Among other things, the group runs an ecological project that explores methods for using plant proteins in food and fodder. Requests for collaborations also arrive from within the biogas field, which – like micro-biological research – is thriving, he says.

- If one looks at the field of biorefinery as a whole, we are the strongest group in Denmark, because we work exclusively with that. If others want to do research in it, they need to work with us. Our strength is derived from our coverage of the field's essential aspects, he says.

### External collaborations

The Center for RNA Medicine has numerous collaborative partners in Boston, where research in non-coding RNA is big. The group also collaborates with Aalborg University Hospital, for example.

At the Section for Sustainable Biotechnology, researchers work with a number of Danish universities, including DTU and Aarhus University, as well as with American and Dutch universities. The section has also participated in international EU projects.

The research group also has collaborations with the business sector, for example with Novozymes and a number of smaller companies.

# AALBORG UNIVERSITY IN COPENHAGEN

Total number of life science researchers: 24 (head count)

- of which professors: 4

– doctoral students: 6

Total number of students in life sciences: n.a.

Life science research is performed at the Faculty of Medicine at the following departments:

Department of Clinical Medicine – Center for RNA Medicine

and at the Faculty of Engineering and Science at the following departments: The Department of Chemistry and Bioscience – Section for Sustainable Biotechnology



The region's largest universities, with the University of Copenhagen at the fore, have published the greatest number of scientific articles and been cited most often. They also place higher on prestigious international ranking lists. But a survey of ranking lists and the universities' publications and citations in recent years show that smaller universities with their specific focuses, such as e.g. the Swedish University of Agricultural Sciences, also enjoy success in their fields.

- As employees of the region's largest university, researchers at the University of Copenhagen have published the highest number of peer-reviewed articles in recent years, followed by their colleagues at Lund University and DTU.
- The publication frequency at Malmö University is slightly elevated with regard to its size. If one looks at the number of articles co-produced with international researchers, Roskilde University is highest. The figures for the number of articles in high impact journals

seem to show DTU as comparatively higher than the other universities.

- The University of Copenhagen was the Scandinavian university to publish the highest number of scientific articles in the two journals Nature and Science from 2013–2016.
- The University of Copenhagen placed highest in the region on the Shanghai Ranking 2016 list – number 30 in a global comparison. The University of Copen-

hagen also has the highest placement in the region – 68 – on QS World University Ranking 2016-2017. On the Times Higher Education's World University Rankings 2016-2017, Lund University places highest in the region at number 96.

 The Swedish University of Agricultural Sciences, with a campus in Alnarp, Scania, ranked number 21 in the category 'Life and Earth Sciences' in CWTS Leiden Ranking (2012-2015), based entirely on scientific articles.

# 8 175 PEER-REVIEWED ARTICLES IN 2015

As employees of the region's largest university, researchers at the University of Copenhagen have published the highest number of peer-reviewed articles in recent years, followed by their colleagues at Lund University and DTU. At first glance, the tables would seem to indicate that the number of articles decreased in 2016, but is impossible to draw any definitive conclusions since the searches were performed before all of the previous year's publications could be registered in the databases. The tables should be read with a certain reserve. They are based on figures from individual universities, which in turn use different sources and methods for the extraction and compilation of data. Nonetheless, it provides a more comprehensive overview of the publication frequency in the life sciences in Medicon Valley than was previously available.

The data compiled shows that the number of peer-reviewed articles, citations and publications in journals with an impact factor (IF) over 30 generally correspond to the size of the university in terms of the number of life science researchers. A precise quota regarding the number of publications per researcher has not – and should not – be calculated, since research areas differ in terms of e.g.

publication- and citation frequency. It can however be discerned that the University of Copenhagen is the region's leading place of learning in all areas. According to figures from 2015, which are more complete that those from 2016, the University of Copenhagen published approximately twice as many peer-reviewed articles as Lund University. It is important to bear in mind that the total number of

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BENCHMARK OF RESEARCH QUALITY: Size does matter – but strong global niche areas are equally important



#### **BENCHMARK OF RESEARCH QUALITY**

articles from Lund University has not been counted (see "About the Figures"). DTU follows with a significantly higher number of publications than the remaining, smaller universities, whose researchers published between several dozen and several hundred scientific articles in 2015. It can be noted that the publication frequency at Malmö University is slightly elevated with regard to its size. with international researchers, Roskilde University is highest. Around 90% of the university's articles involve an international collaboration, whilst this figure is generally between 50 and 70% for the other universities.

The figures for the number of articles in high impact journals show DTU as comparatively higher than the other universities. However, it is impossible to draw far-reaching conclusions from the table, since they do not account for e.g. differences between subject areas.

If one looks at the number of articles co-produced

### COPENHAGEN PUBLISHES MOST IN SCANDINAVIA IN NATURE AND SCIENCE

The University of Copenhagen was the Scandinavian university to publish the highest number of scientific articles in the two journals Nature and Science from 2013–2016, according to the university's own data compilation from the spring of 2017.

During the period in question, the University of Copenhagen published 511 peer-reviewed articles in both of the prestigious journals. In comparison, number two on the list – Karolinska Institute – published 358. Lund University and DTU are at numbers six and nine, with 197 and 158 publications in Nature and Science, respectively.

According to the data compilation from the University of Copenhagen, Professor Jun Wang from the Department of Biology stood for 83 of Copenhagen's

511 articles. His research area is Genome Research and Molecular Bio Medicine.

In a commentary from the university, Thomas Bjørnholm, Prorector of Research and Innovation, said that bringing Jun Wang to Copenhagen required concentrated effort. He maintains that it is a good example of what needs to be done if the University of Copenhagen is to continue to be at the cutting edge of the field. –An effort like that one supports and develops our

entire local body of talent, he says in the commentary.

### ABOUT THE FIGURES

Each university has provided its own data. The table cannot be used as an exact comparison since different methods and sources have been used to extract and compile the data. Thus, they may vary slightly. Broadly speaking however, the table shows the position of the various universities in relation to one another in terms of publications and citations.

The number of peer-reviewed articles, citations and articles co-published with international researchers are for the publications of researchers at selected faculties/ departments at each university.

The number of publications in journals with an impact factor (IF) over 30 are for all researchers at the university in one or more of the following scientific journals: Annual Review of Immunology, CA: A Cancer Journal for Clinicians, Chemical Reviews, Chemical Society Reviews, JAMA The Journal of the American Medical Association, The Lancet, Nature Genetics, Nature Medicine, Nature Reviews Cancer, Nature Reviews Drug Discovery, Nature Reviews Genetics, Nature Reviews Immunology, Nature Reviews Molecular Cell Biology, Nature, New England Journal of Medicine, Physiological Reviews, Science. Too much emphasis should not be placed on the number of articles in journals with an impact factor over 30, as certain topics are overrepresented in journals of

are overrepresented in journals of that level. Many of them are review journals that focus on articles that provide an overview or research within a particular research area. Articles in these types of journals seldom contain new knowledge. The reason for their high IF is that they are heavily cited.

According to e.g. Malmö University, what is considered to have high IF is greatly dependent on the subject, and one should therefore study relative ranking, where publication frequency and IF are weighted against the traditions of each subject area. This can be considered an area of development for future analyses. Impact factor is furthermore

merely an indication of how often an average article is cited in a particular journal, not an indication of the individual articles' contribution to that factor. The number of citations itself is also difficult to compare between different subject areas since they differ in terms of how often and how quickly they are cited.

Furthermore, there are different positions regarding how long one should wait before reporting citations. The University of Copenhagen maintains that three years is a reasonable amount of time, since it usually takes two to three years before an article is cited in new research, while other higher learning institutions have also submitted data for more recent years. Regardless, one should bear in mind when reading the figures that the number of citations increases for every year, and that the data for 2010, 2015 and 2016 are therefore not comparable with each other.

Additionally, it should be noted that the figures for Lund University are only for the Faculty of Medicine and the Departments of Biology, Chemistry, Biomedical Engineering, Immunotechnology and Food Technology, Engineering and Nutrition; the actual figures are probably higher.

	2016			2015			2010		
	Peer-reviewed articles	of which co-published with international researchers	Per cent co-publis- hed with interna- tional researchers	Peer-reviewed articles	of which co-published with international researchers	Per cent co-published	Peer-reviewed articles	of which co-publis- hed with internatio- nal researchers	Per cent co-publis- hed
University of Copenhagen	4 780	2 888	60,4%	5 496	3 244	59,1%	n.a.	n.a.	n.a.
Lund University	2 076	1 247	60%	2 838	1 784	63%	2 378	1 356	57%
Technical University of Denmark	790	555	70%	838	522	62%	527	282	54%
Malmö University	281	135	48%	237	126	53%	139	49	35%
The Swedish University of Agri- cultural Sciences in Alnarp	134	78	58%	158	100	63%	116	72	62%
Roskilde University	82	70	85%	99	90	91%	106	88	83%
Kristianstad University	32	12	38%	41	8	20%	12	8	67%
National Institute of Public Health/ University of Southern Denmark	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Aalborg University in Copenhagen	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Sources and comments: next page.

### ARTICLES AND CO-PRODUCTIONS

# CITATIONS\*

	2014	2015	2010
	2010	2015	2010
Lund University	3 926	19 454	74 044
DTU	1 333	6 794	18 082
SLU in Alnarp	193	594	2 851
Kristianstad University	9	81	n.a.
Malmö University	***	***	***
University of Copenhagen	n.a.	n.a.	n.a.
University of Southern Den- mark, NIPH	n.a.	n.a.	n.a.
Roskilde University	n.a.	n.a.	n.a.
Aalborg Universi- ty in Copenhagen	n.a.	n.a.	n.a.

\*Not comparable between the years due to different periods of comparison

\*\*\* Citations 2015-2016 for articles published between 2012–2015 in SCI, SSCI and A&HCI: 3 217. Citations to the same sources to the published articles in the same year: 548.

# SOURCES AND COMMENTS ON ARTICLES AND CITATIONS

**University of Copenhagen:** Data from CURIS, the institutional repository of the University of Copenhagen, transferred to SciVal for calculation. Data for 2016 in CURIS is not complete and thus numbers are too low. Citations have not been given for publications from 2015 and 2016. Figures are missing for 2010 because of a comprehensive reorganisation of the life sciences at KU in 2012.

**Lund University:** Web of Science, articles and reviews, exported 170407. The figures are based on a search of researchers from the Faculty of Medicine, the Department of Biology, the Department of Chemistry, the Department of Biomedical Engineering, the Department of Food Technology, Engineering and Nutrition and the Department of Immunotechnology.

**DTU – Technical University of Denmark:** Clarivate Analytics' Web of Science Core Collection (SCI and SSCI). The figures are based on a search of researchers from DTU Vet, DTU Food, DTU Aqua, DTU Bioengineering, DTU Bioinformatics and DTU Biosustain. Citations: Sum of Times Cited without self-citations as per 21-04-2017.

**Malmö University:** SCI, SSCI och A&HCI. The quoted number are approximations as the university does not have the exact dates for when the citations were noted.

SLU – The Swedish University of Agricultural Sciences – in Alnarp: Peer reviewed articles that have been registered in SLU's publication database SLUpub and have WoSID as a basis. Search results for these WoSID have been analysed in Web of Science Core Collection and InCites (Clarivate Analytics). Roskilde University: The university's own register. Kristianstad University: Articles – DiVA, Citations – Web of Science. Only the Health Sciences are included in the figures.

### ARTICLES IN JOURNALS IF>30\*\*

	2016	2015	2010
University of Copenhagen	65	65	n.a.
Lund University	16	28	34
DTU	21	25	9
SLU in Alnarp	0	0	1
Malmö University	0	0	0
Roskilde University	0	0	0
Kristianstad University	0	0	0
Aalborg Universi- ty in Copenhagen	n.a.	n.a.	n.a.
University of Southern Den-	n.a.	n.a.	n.a.

mark, NIPH \*\*Number of publications for all researchers at the university in one or more of the following scientific journals: Annual Review of Immunology, CA: A Cancer Journal for Clinicians, Chemical Reviews, Chemical Society Reviews, JAMA The Journal of the American Medical Association, The Lancet,

Nature Genetics, Nature Medicine, Nature Reviews Cancer, Nature Reviews Drug Discovery, Nature Reviews Genetics, Nature Reviews Immunology, Nature Reviews Molecular Cell Biology, Nature, New England Journal of Medicine, Physiological Reviews, Science.

# COMMENTS ON CWTS LEIDEN RANKING (NEXT PAGE)

#### World ranking. Based only on the number of publications.

The CWTS Leiden Ranking is based exclusively on bibliographic data from the Web of Science database of Thomson Reuters (Scientific), Inc., Philadelphia, PA, USA. A fractional counting method is used in the table. It gives less weight to collaborative publications than to non-collaborative ones, which leads to a more proper field normalization of impact indicators. The CWTS Leiden Ranking is based on so-called core publications, which are a subset of all publications in Web of Science. Core publications are publications in international scientific journals in fields that are suitable for citation analysis.

**PP (top 10%).** The proportion of a university's publications that, compared with other publications in the same field and in the same year, belong to the top 10% most frequently cited.

**PP (top 1%).** The proportion of a university's publications that, compared with other publications in the same field and in the same year, belong to the top 1% most frequently cited.

**Note:** Malmö University, Kristianstad University and RUC are not ranked. SLU has no research in biomedical and health sciences in the region. University of Southern Denmark has no research in life and earth sciences in the region.

# SLU IN TOP 30 ON LIFE AND EARTH SCIENCES LIST

CWTS Leiden Ranking shows clearly how a specialised learning institution like the Swedish University of Agricultural Sciences (SLU), with a campus in Alnarp, Scania, can be successful in its own specific field. In the category 'Life and Earth Sciences' – which also includes plant science and biology – the university placed number 21 in an international worldwide comparison based entirely on scientific articles between 2012-2015.

Researchers at the University of Copenhagen published more than one third as many articles in the area 'Biomedical and Health Sciences' than Lund University, the second-most productive university in the region from 2012-2015. The University of Copenhagen also places highest in the region in 'Life and Earth Sciences', and SLU follows close behind.

However, SLU's prominence does not extend

to the most frequently cited articles in the region – DTU and the University of Copenhagen rank best in the region in that department.

Compared with the period from 2008-2011, the region's universities have increased their production of scientific articles on the whole. Furthermore, the articles are increasingly the most frequently cited in their fields.

# CWTS LEIDEN RANKING

#### Biomedical and health sciences

	2012-2015				2008-2011			
	Number of publica- tions	PP (top 10 %)	PP (top 1 %)	World ranking	Number of publi- cations	PP (top 10 %)	PP (top 1 %)	World ranking
University of Copenhagen	6 525	12.9%	1.3%	25	4 570	12.6%	1.2%	38
Lund University	3 959	10.1%	0.7%	78	3 716	9.0%	0.9%	60
University of Southern Denmark (partly in the region)	1 989	10.2%	0.8%	206	1 327	11.4%	1.0%	257
Aalborg University (partly in the region)	795	8.5%	0.5%	464	404	6.3%	0.2%	559
DTU	646	12.5%	2.0%	511	546	10.3%	0.9%	479

#### Life and earth sciences

	2012-2015				2008-2011			
	Number of publica- tions	PP (top 10 %)	PP (top 1 %)	World ranking	Number of publi- cations	PP (top 10 %)	PP (top 1 %)	World ranking
University of Copenhagen	2 206	13.2%	1.5%	9	1 838	11.8%	1.2%	13
SLU (partly in the region)	1 924	11.6%	1.1%	21	1 547	11.1%	1.1%	29
DTU	1 224	14.1%	1.6%	69	960	15.4%	1.3%	78
Lund University	1 023	12.9%	1.2%	99	943	13.2%	1.3%	84
Aalborg University (partly in the region)	216	12.2%	1.5%	588	132	11.7%	0.5%	653

# **UNIVERSITY OF COPENHAGEN RANKS HIGHEST**

Of the learning institutions in the Medicon Valley area, the University of Copenhagen generally places highest on the most respected international ranking lists, followed by Lund University and the Technical University of Denmark. With respect to its size, the Swedish University of Agricultural Sciences, which has a campus in Alnarp in Scania, also places high on the lists. The universities themselves have an ambivalent relationship to the ranking lists; while they question the fairness and accuracy of the lists, they must also take them into consideration, since they are significant for example when attracting international students and researchers.

The criteria for the most prestigious ranking lists differ in a number of ways. For example, Shanghai Ranking places the greatest emphasis on scientific articles and citations, as well as large awards, whilst academic reputation is paramount in QS World University Ranking.

– I am someone who takes ranking lists with a large grain of salt. They are done differently, and therefore the results are also different. Unfortunately, focus on ranking lists has increased, says Kristian Helin, Vice Dean of Research at the University of Copenhagen's Faculty of Health and Medical Sciences.

His view succinctly summarises the position shared by many of the researchers interviewed for this report. However, there is a keen awareness of how important the ranking lists are for marketing the universities.

- When students are deciding where to apply to do their PhD studies, they look at these lists. They are also very important when universities want to recruit researchers from abroad, says Morten Pejrup, Vice Dean of Research at the Faculty of Science at the University of Copenhagen.

This analysis looks at three different ranking lists and their subcategories and supplements: QS World University Ranking, Times Higher Education, and Shanghai Ranking. On page 31, there is also a presentation of CWTS Leiden Ranking, which is based entirely on these criteria.

Not surprisingly, the largest universities in Medicon Valley place best on the ranking lists, with the University of Copenhagen at the top. The University of Copenhagen placed highest in the region on the Shanghai Ranking 2016 list – it was number 30 in a global comparison, and sixth if only European learning institutions are included in the comparison. Lund University and the Technical University of Denmark are the next two universities from Medicon Valley, a bit further down on the same list.

The University of Copenhagen also has the highest placement in the region – 68 – on QS World University Ranking 2016-2017, which is 40% based on academic reputation. Lund University follows close behind, and then comes the Technical University of Denmark.

On the Times Higher Education's World University Rankings 2016-2017, Lund University places highest in the region at number 96, followed by the University of Copenhagen, the Technical University of Denmark and – as with the previously mentioned ranking lists – a number of other universities in the region. The list is primarily based on factors related to teaching, research and scientific citations.

QS World University Ranking and Shanghai Ranking also issue lists in more specialised areas. On Shanghai Ranking's Life and Agricultural Sciences list, the University of Copenhagen appears at number 38, and it is number 27 on QS World University Rankings Life Sciences and Medicine list.

Malmö University also appears on the latter, as does the University of Southern Denmark, whose National Institute of Public Health is located in the region. The University of Southern Denmark ranks higher on lists that specifically compare the area medicine than on general ranking lists.

However, smaller learning institutions have by and large a harder time making their presence felt in the competitive global environment than the large do. An evaluation performed by Roskilde University showed for example that the university as a whole is lagging behind when it comes to citations, and according to Malmö University, it loses points for academic reputation because the institution is not very well known. Kristianstad University is not included on any of the lists presented in this report.

As far as QS World University Ranking and Shanghai Ranking are concerned, however, it is possible to see the distribution of the ranking in still narrower subject areas, which favours smaller learning institutions in some cases. The University of Copenhagen once again places highest on these lists in general, but it should be noted that the Swedish University of Agricultural Sciences was ranked number four in the world for Agriculture & Forestry in the QS World University Ranking. Another high placement is the Technical University of Denmark, which ranked number twelve on the Shanghai Ranking in the subject area Chemical Engineering.

Additionally, the Swedish University of Agricultural Sciences (SLU) also placed high on Times Higher Education's ranking The World's Best Small Universities 2017. SLU ranked ninth in the world among small universities; to be considered for this category, institutions must fulfil the criteria of having been ranked in the University Rankings 2016-17, offering tuition in more than four subjects, and having a student body of fewer than 5 000 students.

- If one looks at smaller universities, agricultural universities, and newer universities, we place very high. We are a small university compared with the giants, but we are successful in our field, says Eva Johansson, Vice Dean for Research at the Faculty of Landscape Architecture at the Swedish University of Agricultural Studies in Alnarp.

SLU is also one of three universities in the region that feature on Times Higher Education's list Young University Rankings 2017, which lists the 200 best learning institutions in the world that are at most 50 years old. The others are Aalborg University and Roskilde University. The University of Copenhagen and Lund University are also relatively pleased with their placements on the ranking lists.

- China and Asia are gaining strength and the

#### competition is stiffening. That's why it is so important to invest in research. The investments that we make in research centres for example are one way to strengthen the focus. I think that we are on the right path, says Gunilla Westergren-Thorsson, Dean of the Faculty of Medicine at Lund University.

- The University of Copenhagen is generally at the top in Scandinavia, along with the Karolinska Institute, but that is a smaller and more specialised university. We would like to be in the top ten in the world if we could, but it is an enormous challenge; we face American universities that have been recruiting from the entire world for many, many years. That leads to a better student body and more funding. They have also been better at prioritising elite research, which we cannot afford in Denmark, where we have universities that need to cover the entire country. However, that doesn't mean that it can't be done better in Denmark, and that is what we are trying to do. Introducing elite research and other things that are called "elite" has been difficult, but over the past ten years we have succeeded. We have very strong concentrations of elite researchers in research centres and at our university, we have basic research centres and we have some environments that can rival the world's very best, says Kristian Helin from the University of Copenhagen.

# ABOUT THE RANKING LISTS

The three ranking lists selected are some of the most prestigious in the world. Shanghai Ranking has been published since 2009 by the independent organisation Shanghai Ranking Consultancy, but was already established by Shanghai Jiao Tong University in 2003. Times Higher Education has been published in the eponymous journal since 2004 and is reviewed by Pricewaterhouse Coopers (PwC). QS World University Rankings has been released by the British student advisory company Quacquarelli Symonds (QS) since 2011.

#### SHANGHAI RANKING

The Shanghai Ranking rates over 1 200 universities based on several indicators of academic or research performance, including alumni and staff that have won Nobel Prizes and Fields Medals (10 and 20% of the total result respectively); highly cited researchers (20%); papers published in Nature and Science (20%); papers indexed in major citation indices (20%); and the per capita academic performance of an institution (10%).

#### TIMES HIGHER EDUCATION

Times Higher Education ranks universities around the world based on 13 indicators in five areas: Teaching (the learning environment); Research (volume, income and reputation); Citations (research influence); International outlook (staff, students and research); Industry income (knowledge transfer), of which the first three carry the greatest weight (30% each) and the latter two 7.5 and 2.5% respectively.

#### World Reputation Rankings

The 2017 rankings are based on a survey carried out between January 2017 and March 2017, which received a total of 10 566 responses from 137 countries.

#### **QS WORLD UNIVERSITY RANKINGS**

QS World University Rankings rates more than 3 800 universities based on six performance indicators, two based on major global surveys – academic reputation (40% of the score) and employer reputation (10%) – and four on 'hard' data – student-to-faculty ratio (20%); citations per faculty (20%); international faculty ratio (5%) and international student ratio (5%).

#### **BENCHMARK OF RESEARCH QUALITY**

### SHANGHAI RANKING

<b>OVERALL RANKING LIST (2016)</b> (Total of 500 on the list)	Field LIFE* (2016) Life and Agriculture Sciences (Total of 200 on the list)	Field MED* (2016) Clinical Medicine and Pharmacy (Total of 200 on the list)
1 Harvard University, USA (1)	1 Harvard University, USA (1)	1 Harvard University, USA (1)
2 Stanford University, USA (2)	2 University of Cambridge, UK (2)	2 University of Washington, USA (3)
3 University of California, Berkeley, USA (4)	3 Massachusetts Institute of Technology (MIT), USA (4)	3 Stanford University, USA (5)
30 University of Copenhagen (35)	34 Karolinska Institute (31)	12 Karolinska Institute (12)
44 Karolinska Institute (48)	38 University of Copenhagen (39)	50 University of Gothenburg (45)
60 Uppsala University (61)	76-100 Aarhus University** (101-150)	51-75 University of Copenhagen (76-100)
65 Aarhus University** (73)	76-100 Lund University (51-75)	76-100 Aarhus University** (101-150)
81 Stockholm University (77)	76-100 University of Gothenburg (101-150)	76-100 Uppsala University (51-75)
101-150 Lund University (101-150)	101-150 Stockholm University (101-150)	101-150 Lund University (151-200)
151-200 Technical University of Denmark (DTU) (151-200)	101-150 Swedish University of Agricul- tural Sciences (SLU)* (76-100)	151-200 Aalborg University* (not on list)
151-200 University of Gothenburg (151- 200)	101-150 Technical University of Den- mark (DTU) (101-150)	151-200 Umeå University (151-200)
201-300 Aalborg University* (301-400)	151-200 Umeå University (101-150)	151-200 University of Southern Denmark* (101-150)

151-200 Uppsala University (151-200)

201-300 KTH (201-300)

201-300 Chalmers (301-400)

201-300 SLU\* (201-300)

301-400 Linköping University (301-400)

301-400 Umeå University (301-400)

301-400 University of Southern Denmark (201-300)\*

401-500 School of Economics, Stockholm (401-500)



# **QS WORLD UNIVERSITY** RANKINGS

WORLD UNIVERSITY RANKINGS (2016-2017) (Total of 916 on the list)

1 Massachusetts Institute of Technology (MIT), USA (1)

2 Stanford University, USA (3)

3 Harvard University, USA (2)

68 University of Copenhagen (69)

78 Lund University (70)

97 KTH Royal Institute of Technology (92)

98 Uppsala University (102) 109 Technical University of Denmark

(DTU) (112) 117 Aarhus University\*\* (107)

139 Chalmers (132)

196 Stockholm University (182)

264 University of Gothenburg (247)

282 Linköping University (286)

294 Umeå University (319)

374 Aalborg University\* (356)

390 University of Southern Denmark\* (361)

VERSITY RANKINGS By Faculty - Life Sciences and Medicine (2017) (Total of 500 on the list – 400 the previous vear) 1 Harvard University (USA) 2 University of Cambridge (UK) 3 University of Oxford (UK) 7 Karolinska Institute (9) 27 University of Copenhagen (24) 49 Uppsala University (56) 58 Aarhus University\*\* (60) 88 Lund University (86) 108 University of Gothenburg (99) 213 Umeå University (218) 222 Stockholm University (196) 266 University of Southern Denmark\* (254) 280 Technical University of Denmark (DTU) (263) 284 Linköping University (304) 287 Swedish University of Agricultural Sciences (SLU)\* (254) 381 Malmö University (390) 401-450 Aalborg University\* (not on list) 451-500 KTH (not on list) By Faculty - Natural Science (2017) (Total of 500 on the list - 400 the previous year) 1 Massachusetts Institute of Technology (MIT), USA (1) 2 University of Cambridge, UK (3) 3 Harvard University, USA (2) 69 Stockholm University (90) 90 KTH Royal Institute of Technology (93) 90 Lund University (93) 117 Technical University of Denmark

CONT. QS WORLD UNI-

48 University of Copenhagen (54)

87 Aarhus University\*\* (95)

(DTU) (80)

135 Uppsala University (99) 190 Chalmers University of Technology

(146) 381 University of Gothenburg (363)

398 Linköping University (333)



### TIMES HIGHER EDUCATION

WORLD UNIVERSITY RANKINGS (2016-2017) (Total of 981 on the list) 1 University of Oxford, UK (2) 2 California Institute of Technology, USA (1) 3 Stanford University, USA (3) 28 Karolinska Institute (28) 93 Uppsala University (81) 96 Lund University (90) 98 Aarhus University\*\* (106) 120 University of Copenhagen (82) 144 Stockholm University (136) 159 KTH Royal Institute of Technology (155) 170 University of Gothenburg (180) 176 Technical University of Denmark (DTU) (167) 201-250 Aalborg University\* (201-250) 251-300 Chalmers (201-250) 251-300 Copenhagen Business School (CBS)\*\* (201-250) 251-300 University of Southern Denmark\* (301-350) 251-300 Swedish University of Agricultural Sciences (SLU)\* (201-250) 251-300 Umeå University (251-300) 301-350 Linköping University (251-300) 351-400 Örebro University (301-350) 501-600 Roskilde University (not on list)

(Total of 101 on the list) 1 Harvard University, UK (1) 2 Massachusetts Institute of Technology (MIT), USA (2) 3 Stanford University, USA (3) 51-60 Karolinska Institute (51-60) 81-90 University of Copenhagen (not on list) 91-100 Lund University (91-100) Best universities for life sciences (2016-2017) (Total of 100 on the list) 1 Harvard University, UK 2 University of Cambridge, USA 3 University of Oxford, UK 23 Karolinska Institute 40 Uppsala University 42 Lund University 49 Stockholm University 86 Swedish University of Agricultural Sciences (SLU)\* 98 Aarhus University Red: performs life sciences research in Medicon

World Reputation Rankings (2017)

Vallev (Last year's ranking.) \* Has a branch in the region. \*\* Located or has a branch in the region, but does not perform life science research in the region.

RESEARCH GROUPS: Cancer in focus



Nils Brünner and Carl Borrebaeck both emphasise the importance of collaboration between laboratories and clinics – and of commercialising research results to bring them to patients. Each of them heads a successful group in cancer research, which is one of the region's largest research areas along with e.g. diabetes and metabolic diseases, neuroscience, stem cell research, bio-based raw materials and biorefinery.

 Carl Borrebaeck is the man behind the cancer research institution CREATE Health, where researchers from four faculties at Lund University and the Skåne University Hospital in Lund combine their energy. The research centre has been celebrated in evaluations and given rise to a number of successful companies. Among the successful results brought forth there is a test expected to save the lives of many more patients with pancreatic cancer.

 Nils Brünner, Professor of Pathology and Biomedicine at the University of Copenhagen, has in recent years founded a biotech company, headed a Chinese collaboration in the form of a research centre for breast cancer research, and helped initiate the new national Danish Comprehensive Cancer Centre. The most important characteristic of his research group is, according to Nils Brünner, that they are good at transferring knowledge and questions between the laboratory and the clinic.

# SPOTLIGHT ON CANCER – One of many thriving research areas in the region

Cancer is one of the many large and important research areas in the life sciences in Medicon Valley, along with e.g. metabolic diseases and diabetes, stem cell research and neuroscience, biorefinery and bio-based raw materials. For all of these areas – and for smaller-scale research areas such as reproduction, coagulation, chemical ecology, genomics and metagenomics – there are also many successful research groups.

A research group in molecular neurogenetics at Lund University recently developed a method for producing diseased, aging brain cells in a tissue culture dish in order to perform experiments on them. Another international research group led by researchers from X-ray and Neutron Science at the Niels Bohr Institute at the University of Copenhagen x-rayed cells that were infected with malaria and found potential targets for the development of new, intelligent medicines. A research group at SLU in Alnarp received 32 million Swedish crowns to develop new plants and crops to produce oil that will be able to replace fossil fuel. The examples of highly qualified and interesting research groups in the region are many.

In this analysis, we have chosen to highlight two research groups from within the field of cancer research, both of which focus on bringing research results to patients as quickly as possible, primarily by commercialising them. One of the research groups, led by Professor of Immunotechnology Carl Borrebaeck, is on the Swedish side of the Øresund Strait at Lund University/LTH, and the other, led by Professor of Pathology and Biomedicine Nils Brünner at the University of Copenhagen, is on the Danish side.

Cancer research is performed at many of the region's universities, as well as at other institutions such as the Danish Cancer Society (Kræftens Bekæmpelse); Nils Brünner's research group works with the society and is thus a concrete example of this.

Carl Borrebaeck and Nils Brünner also exemplify the collaborative work that takes place across the Øresund Strait; Both are driving forces behind the Medicon Valley Alliance Oncology Network, which gathers Swedish and Danish actors from within the industry, academia and health care with the ambition to increase collaboration and knowledge exchange in the field of cancer research, as well as to stimulate commercialisation and growth.

# **"IT HAS BEEN RELATIVELY EASY TO BRING IN BIG MONEY**"

Making a difference for patients with his work is part of the fun for Carl Borrebaeck. He is the man behind the cancer research institution CREATE Health, where researchers from four faculties at Lund University and the Skåne University Hospital in Lund combine their energy. Among the successful achievments there is a test expected to save the lives of many more patients with pancreatic cancer. The research centre has also been celebrated in evaluations and given rise to a number of successful companies.

Carl Borrebaeck, Professor

of Immunotechnology at

Lund University.

When Carl Borrebaeck and Ulrika Ringdahl, who was research coordinator at the time, started CRE-ATE Health in the mid-00's, their timing couldn't have been better.

- At the time, around 2005-2006, a lot of things were happening in cancer research, and personalised medicine was starting to catch on in the academy. And since we had a great line-up, our applications for funding to start the centre were very well received. Of 114 applications to the Swedish Foundation for Strategic Research, we were ranked number one. Since then, it has been relatively easy to bring in big money - tens and even hundreds of millions - for the research, because it is precisely the right time, says Carl Borrebaeck, who is a professor of Immunotechnology at Lund University.

Today, the centre consists of nine research

heads, Carl Borrebaeck included, and about 60 additional researchers who participate panies understanin the various projects and ding that we have programmes. It includes researchers from the Faculty of Medto get this out to icine, the Faculty of Science, the patients and to and the Faculty of Engineering the society." at Lund University (LTH), as well as the clinical operations at Skåne University Hospital (SUS) in Lund. In addition, a psychologist from the Faculty of Social Sciences at Lund University is participating in the programme Mad for Cancer, which is part of CREATE Health. Within the programme, research is performed on e.g. psychological resilience; that is, individuals' power of resistance to an illness - in this case, to breast cancer.

- We know that cancer patients

with the same diagnosis and the same kind of tumours cope with the illness in different ways. That is ascribed in part to psychological resilience. While it is well-documented that it has an effect, it lacks somatic foundation; that is, which markers, which genes, which signalling pathways, proteins and so on can explain it, says Carl Borrebaeck. A clinical study is currently being done in

Sweden at the hospitals in Halmstad, Växjö and Karlskrona, where patients who have been newly diagnosed with breast cancer fill out a psychological survey and submit a blood sample, both of which are sent to Lund. Researchers then attempt to find correlations between the psychological survey, where patients' mental resilience is plotted in on a scale, and what they have begun to discover about the biomarkers.

- We do a lot of work with biomarkers, in part to improve diagnostics; if we discover "I started the com-

the cancer early, it can be cured. But also in order to be able to give patients better treatments, and to, as it is called, 'stratify patients': "You need this treatment and you need that treatment". That is called personalised medicine, says Carl Borrebaeck.



pany Immunovia, which has now developed a test for early diagnosis of the illness. He estimates that it can raise the number of patients who live five years after being diagnosed from 4-6% to 50-60%.

Immunovia is just one of the seven or eight companies with origins in the research at CRE-ATE Health. Carl Borrebaeck has also started SenzaGen, which markets a method that can replace animal testing; Bioinvent International, which develops antibody-based pharmaceuticals against cancer; and Alligator Bioscience, which develops pharmaceuticals with what he describes as the hottest area right now: Immuno-oncology. Last year, Alligator signed a contract with the pharmaceutical company Johnson & Johnson worth six billion Swedish crowns, which is the largest ever in its field in Sweden. Bioinvent also recently signed a contract with Pfizer.

- I started the companies understanding that we have to get this out to patients and to society. There are two ways to do that: either we license the research results, usually to an American company, and then the research disappears from Sweden, or we create commercial organisations ourselves so that we can develop it. In part this also verifies that the research is applicable, and it also speaks for its quality that we can do something with it. It can solve societal problems, says Carl Borrebaeck.

He believes that what sets CREATE Health apart is that researchers span many areas of expertise, and that clinicians, technicians, experts from genomics, proteomics, and health scientists work across disciplinary boundaries.

- It has made it possible for us to develop new diagnostic methods, and also immuno-oncological drugs, and so on, he says.

But the research centre also has external collaborations. One of the projects that Carl Borrebaeck highlights is a collaboration with Swiss researchers in the field of immuno-oncology, where the immune system is used to release the brakes and attack tumours. Another collaboration, with China, is focused on pancreatic cancer.

CREATE recently celebrated its 10 year anniversary, when Dr Ulrika Axelsson was appointed as as deputy head of the center.

Carl Borrebaeck believes that one explanation for the success of CREATE Health is its structure as a centre for research and expertise. Every head of research has been granted extensive freedom, but also remaines within the framework of translational cancer research, over boundaries.

- We have been evaluated three times and judged excellent to outstanding. This format works very well, he says.



# "WE ARE FOUNDING ONE, POSSIBLY TWO **COMPANIES NOW**"

According to Nils Brünner, MD and Professor of Pathology and Biomedicine at the University of Copenhagen, the close relationship between research and clinics is distinctive for the research group that surrounds him. In recent years, he has for example co-founded a biotech company, headed a Chinese collaboration in the form of a research centre for breast cancer research, and helped initiate the new national Danish Comprehensive Cancer Centre.

predictive biomar-

kers, used to predict

whether a patient will

a certain type of medi-

cal cancer treatment"

Nils Brünner. Professor of

Pathology and Biomedicine at

the University of Copenhagen.

Nils Brünner's research group has its stylish premises at the organisation Kræftens Bekæmpelse in Copenhagen. The group is part of the University of Copenhagen's Institute for Drug Design and Pharmacology, but they are also part of a unit for Translational Cancer Research, where they assist researchers from the Danish Cancer Society in transferring their discoveries to patients.

The group focuses primarily on three research areas: drug resistance in breast- and intestinal cancer, preventive cancer medicine, and new biomarkers for breast-, colorectal-, and prostate cancer.

Their most important characteristic according to Nils Brünner is that they are good at transferring knowledge and questions between the laboratory and the clinic.

- We perform our basic and applied research and transfer it to patients as "We can develop

quickly as possible, but our departure point is in the medical questions formulated. We have discussions with our clinical colleagues: What problem does the patient have, why do so many of these patients die; then *Or will not respond to* we go back to the laboratories and continue researching and discussing until we arrive at a plausible solution, he says.

Nils Brünner speaks animatedly about the importance of commercialising one's discoveries, since that is the only way they can benefit patients.

- We are founding one, possibly two new companies now. One is within drug development and and the other within biomarker development, he says, and continues:

- We can't keep everything to ourselves; we need to send the discoveries fur-

ther out into the system so they reach the patients. That is obviously the objective: doing something for the patients.

The group consists of two professors, two associate professors, a lecturer, a number of postdoctoral researchers, doctoral students, laboratory workers and master's students who also develop biomarkers that can help in choosing the right treatment for the right patient at the right time.

- One of our focuses is investigating how cancer cells become resistant, and then we make medicine that goes in and blocks that, so that the cancer cells can be killed by chemotherapy again. So we can cure more patients, says Nils Brünner.

The research group has at present identified two drugs that can abolish certain types of drug resi-

> stance and they are now forming a new biotech company in order to secure that these drugs are taken through relevant clinical studies.

- Another value of these studies is that when they reveal molecules being involved in drug resistance, we can develop predictive

biomarkers, used to predict whether a patient will or will not respond to a certain type of medical cancer treatment. The predictive biomarker discoveries form the basis for a second spin-out where new assay platforms are developed and the clinical value of the biomarkers are validated, he says.

He also talks about a large project run by the group in which prescription and cancer registers in Denmark, Sweden, Norway and Finland are coordinated. The result has shown that patients who have received a certain type of medicine are not stricken with colorectal cancer as often. After preliminary tests, the research group can do an intervention study with the pharmaceutical right away, without the necessity of time-consuming and expensive Phase 1 and Phase 2 studies.

In addition to the research group at the University of Copenhagen and the unit for Translational Cancer Research at Kræftens Bekæmpelse, Nils Brünner is also head of the Sino-Danish Breast Cancer Research Centre, which is a cooperative effort between Danish researchers, primarily from the University of Copenhagen but also from other Danish universities, and Chinese researchers from Beijing Genomics Institute. The research aims to develop methods for customising breast cancer treatments for every individual, and it has laid the foundation for some of what the Danish research group at the Institute for Drug Design and Pharmacology is working with now.

- We would not have gotten where we are today without it, and the centre is still active, he says.

Nils Brünner was also one of the initiators of

the Danish Comprehensive Cancer Centre, which was inaugurated at the beginning of 2017. The objective of the new national centre is to establish better cooperation between those who conduct cancer research in Denmark, to make better and more comprehensive studies possible, but also to enable collaboration with equivalent centres in other European countries and in the USA.

- We are joining the international league and are now a partner with equal worth as Europe and the USA. On top of that, we get coordinated patient treatment and research, so there is a general boost in quality.

Nils Brünner already began researching as a medical student, and he describes himself as a true enthusiast who cannot stay away from research. He praises his research group:

- We are good at having a vision and at seeing connections that others don't see. Researchers can't see them and clinics can't see them; but when one has a double education, it can be done. However, drug and biomarker development is a team effort and we have therefore established a large national and international network where we share visions.



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NATIONAL RESEARCH POLICY: Stategic investments in the life sciences



The Danish and Swedish governments are both investing in life science research, which is emphasised in plans, commissions and research propositions. The Danish government is currently working on a growth plan after the Growth Team for Life Science submitted its recommendations earlier this year. Important national investments by Denmark and Sweden in the Medicon Valley area include the research facilities ESS and MAX IV, which are expected to contribute greatly to life science research in the region.

 The Danish government's Growth Team for Life Science has recommended allocating more resources to academic life science research and making it more target-oriented, whilst also reinforcing the education of highly qualified researchers. The Danish government is currently working on a growth plan.

• Health is foregrounded

as one of the five societal

challenges prioritised for

government in the Swedish

research funding by the

- research proposition Forskningspropositionen from November 2016.
- Biopharma, bioinformatics and personalised medicine are important research and development areas emphasised by the Swedish Minister of Higher Education and Research Helene Hellmark Knutsson. The Swedish government is investing in e.g. collaboration between academic research and businesses in biopharma.
- We have listed 28 life science research centres of national interest in the region.
- There are a number of projects and initiatives dedicated to helping the region's educational institutions and businesses exploit the potential that the globally leading research facilities MAX IV and European Spallation Source (ESS) will offer. Danish LINX concentrates on the business side, while Swedish Linxs focuses primarily on promoting research.

# NATIONAL RESEARCH POLICY AND INVEST-MENTS IN LIFE SCIENCE

Life science research is a top political priority in Denmark and Sweden. There is a particular focus on health, but also on challenges associated with e.g. biodiversity and climate change-related food issues. Both countries invest large sums in independent research, and also distribute funds for research in areas deemed important for society.

The Danish catalogue RESEARCH2025, published in June 2017, presents four research areas considered most important and promising for Denmark in the coming years:

- New technological opportunities
- Green growth
- Improved health
- Humans and society

The four areas selected have been chosen by the Danish Agency for Research and Innovation, which has gathered the viewpoints of departments, regional and municipal representatives, research councils,

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universities, vocational colleges, industrial organisations and interest groups on the government's behalf. The catalogue does not express any political prioritisation, but is intended as a foundation for decisions to come. The last version of the catalogue, RESEARCH2020, which was published in 2012, also addressed points such as a society with a green economy and a society with health and quality of life as two of four important areas.

In March 2017, the Danish government's Growth Team for Life Science presented its recommendations for how to strengthen the international position of Danish life science in companies, public

authorities and research environments. By 2025, Danish life science "should be world-class, contribute to the development of new, innovative treatment options, improve people's quality of life and make a significant contribution to the Danish economy". The Growth Team's recommendation regarding academic life science research is to allocate more resources and make it more target-oriented, whilst also reinforcing the education of highly qualified researchers. According to the Growth Team, the focus on innovation should be strengthened, and the framework for developing new, innovative, and effective treatments should be improved; the coordination of clinical research should be optimised, and researchers should have better and more secure access to healthcare data.

In 2016, Denmark's total budget for research was reduced from 22 billion to 20.6 billion Danish crowns. A 2% annual savings requirement on higher education was also introduced, and will continue until the year 2020. The total research budget for 2017 has been increased to 21.5 billion Danish crowns.

In the Swedish research proposition Forskningspropositionen from November 2016, entitled 'Cooperative knowledge - for society's challenges and competitive strength' (Kunskap i samverkan för samhällets utmaningar och stärkt konkurrenskraft), the Swedish government presents its view on the direction of research policy with a ten-year perspective, focused particularly on investments from 2017–2020. Health is foregrounded as one of the five societal challenges prioritised for research funding by the government; the others are climate and the environment, increased digitalisation, creating a safe, inclusive and sustainable society, and improving performance in the Swedish school system. A national research program for antibiotics resistance has been established, and additional funding has been allocated for the reinforcement of biobanks and register research. Life science is also the subject of one of five new strategic innovation programmes created to coordinate the innovation efforts that will strengthen Sweden's competitive profile and take on the societal challenges that have been identified.

In the 2017 budget, 42.6 billion Swedish crowns were allocated to universities and colleges, including for research and teaching, and 7.9 billion were designated for other research; the largest apportionment went to the Swedish Research Council.

In December 2016, the Swedish government

decided to extend the position of the national coordinator for the life science sector, whose task it has been to support the government's work and further strengthen Sweden's position in life science – including within research. The coordinator will now also be working to place the European Medicines Agency, EMA, in Sweden.

# Investments in outstanding research environments

In 2008, the authorities the Swedish Research Council, Vinnova, the Swedish Energy Agency, Forte, and Formas were presented with the task of selecting a series of research environments as strategic research environments. The criteria for the research environments were that they were positioned within one of 24 designated strategic areas, and that their conditions could maintain excellent international quality in the long-term, that they were able to help respond to significant societal needs and find solutions to important societal issues, as well as performing research in areas with connections to the Swedish business sector. Of the 43 research environments selected, twelve are located or partially located at Lund University, and three at the Swedish University of Agricultural Sciences. Of these, eleven at Lund University and one at the Swedish University of Agricultural Sciences - where research is done primarily at the campus in Alnarp - can be classified at least in part as within the life science sector.

Another Swedish programme focused on creating strong environments for basic research are the Linnaeus grants. Within the so-called Linnaeus environments, 40 research environments were allocated funding from the Swedish Research Council for a period of ten years. 20 of them were established in 2008 and are still receiving funds, whilst the funding period for the others has expired. Six of the Linnaeus environments that are still receiving support are located at Lund University, and five of these can be classified at least in part as life science.

VINN Excellence Centers are selected by the authority Vinnova, and they represent the cooperation between the business and public sectors, as well as universities and colleges or other research organisations. The research can be applied or basic. To date, 17 VINN Excellence Centers have been selected; two of these have been at Lund University. One of them concerns life science research.

Since 2010, Sweden has also had a national centre for molecular biosciences, where the focus is on

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in health and environmental research: SciLifeLab, which is located in Stockholm and Uppsala. The centre is a collaboration between Karolinska Institute, KTH Royal Institute of Technology, Stockholm University and Uppsala University, and it has also been designated a national resource.
dent, and received three I from the government on most recently in 2015, for ch funds until 2036. The however entitled to appo board of directors and or foundation has contribution the resources for strategic research in-

vestments were transferred to the Innovation Fund in 2014. The Innovation Fund is an independent foundation with government financing. The Innovation Foundation's programme Grand Solutions invests in innovative ideas that demonstrate significant potential to create knowledge, growth, and job opportunities in Denmark. The 420 financed projects, 312 of which are still operative, are led cooperatively by various partners from the business and public sectors, and/or university hospitals and universities. The majority has at least one partner in Medicon Valley. 15 of the projects are international and have e.g. partners in other parts of Sweden.

The Danish National Research Foundation finances Centers of Excellence for "visionary frontier research of the highest quality in Denmark". The Danish National Research Foundation is indepen-

Research in the life sciences is not only performed at the region's universities. For example, a researcher at the vocational school the Copenhagen School of Design and Technology dent, and received three billion Danish crowns from the government on two separate occasions, most recently in 2015, for distribution as research funds until 2036. The Minister of Research is however entitled to appoint the chairperson of the board of directors and one additional member. The foundation has contributed to the establishment of 100 Centers of Excellence, 39 of which are still operative. 23 of these are located in eastern Denmark. Of these, twelve are dedicated at least in part to life science research.

In Denmark as well as Sweden, there are also private foundations that support research funding; for example the Novo Nordisk Foundation, Lundbeckfonden, and the Wallenberg Foundations. Nonprofit organisations and foundations accounted for 8.4% of the total funding for university research in Denmark in 2009, according to a report by the think tank DEA. Both the Novo Nordisk Foundation and Lundbeckfonden only distribute funds for life science research, and both have contributed to establishing research centres. The Novo Nordisk Foundation, which is the larger financier of the two, is behind five Danish research centres. All five are located in the Medicon Valley area.

recently discovered that ADHD medication affects the eye's ability to focus. Further studies are expected.



# FACTS: **RESEARCH CENTRES AND ENVIRONMENTS**

There are many research centres and environments located in the Medicon Valley area and completely or partially in the life science sector, including the following strategic research environments, Linnaeus environments and VINN Excellence Centers (selected by Swedish authorities such as the Swedish Research Council and Vinnova), as well as the basic research centres chosen by the government-financed Danish National Research Council. Additionally, the list includes research centres in life science in Medicon Valley that are financed by the Novo Nordisk Foundation.

# **SWEDEN**

### STRATEGIC RESEARCH ENVIRONMENTS:

Lund University:

BioCare – Biomarkers in Cancer Medicine\*

About: Focuses on biomarkers in cancer, their discovery, utilisation in healthcare and translation to wider communities. Other participants: University of Gothenburg

### Exodiab

- Outstanding Diabetes Research in Sweden

About: Aims to develop tools for prevention and successful treatment of diabetes, with a broad multidisciplinary approach which integrates genetics, bioinformatics, physiology, cell biology, clinical, epidemiological and nutritional research. Other participants: Uppsala University

### **EpiHealth – Epidemiology for Health**

About: Studies how common widespread diseases can emerge as interplay between lifestyle factors and genetics.

**Other participants:** Uppsala University

### eSSENCE - an E-science Collaboration

About: Obtaining quantitative data from large-scale experiments of live cells is of great importance for understanding molecular and cellular processes such as basic cellular processes in bacterial cells, and for design of personalised treatments based on stem cells from cancer patients.

Chiefly responsible: Uppsala University Other participants: Lund University and Umeå University

### **MultiPark**

About: The vision is to create new and innovative strategies for improved and novel treatments,

disease modifications and eventually cures for neurodegenerative diseases. Other participants: University of Gothenburg

### **Stem Therapy**

About: The objectives are to demonstrate that stem cell-based cell replacement therapy is effective and safe, to provide therapeutic candidates for stroke, diabetes and haematological diseases, and to build a strong base of knowledge about stem cells and disease mechanisms.

Other participants: Uppsala University

\* BioCare – biomarkers in cancer medicine will no longer be considered a strategic research area in Sweden as of 2020 due to its low rating on an evaluation performed on behalf of the Swedish Research Council.

### Swedish University of Agricultural Sciences in Alnarp: TC4F – Trees and Crops for the Future

About: The objective is to be an internationally leading scientific environment that enables the use of renewable plant resources for new, innovative products in a sustainable way. Other participants: Umeå University

### LINNAEUS ENVIRONMENTS:

Lund University: Bagadilico – New Therapies for Diseases of the Basal Ganglia

About: Aims to develop new and improved treatments for Parkinson's and Huntington's diseases.

### CAnMove

### - Centre for Animal Movement Research

About: Studies animals' movement patterns with the aim to understand animals' adaptations to

dispersal and migration and examine the consequences of these movements on animal populations, individual survival and the spread of diseases.

### **VINN EXCELLENCE CENTRES:**

#### Lund University: **Antidiabetic Food Center**

# **Chiefly responsible:** Lund University

Other participants: Region Skåne, Aventure AB, Fazer Bakeries Ltd., MKS Instruments, Mondelèz International, Oatly AB, Orkla ASA, Kalmar-Öland gardening products

About: Aims to counter the development of diabetes with innovative food concepts through joint venture research and the promotion of research-based business activities.

# DENMARK

### DANISH NATIONAL RESEARCH FOUNDA-**TION- CENTRES OF EXCELLENCE:**

Technical University of Denmark: IDUN - Center for Intelligent Drug Delivery and Nanomechanical Sensors About: Focuses on the main research areas of drug

delivery and nanomechanical sensors.

# University of Copenhagen: BASP – Center for Bacterial Stress Response and Persistence

**About:** The main objective of the research is to understand molecular mechanisms underlying Bacterial Stress Responses and Antibiotic Multidrug Tolerance (Persistence).

### STEMPHYS - Center for Stem Cell Decision Making

About: StemPhys joins forces of physics and stem cell biology with the goal of understanding and controlling stem cell commitment.

### CCS – Center for Chromosome Stability

About: The mission is to conduct basic research in order to understand in mechanistic detail how cells minimize damage that can generate chromosomal instability.

### **DvnaMo**

### - Center for Dynamic Molecular Interactions

About: Studies the dynamic processes that occur on a molecular level in multicellular organisms to gain insight into the universal principals behind the processes.

# CCG – Center for Glycomics

About: Aims to make this research area approachable to non-experts in order to facilitate discovery of diseases caused by altered glycosylation, develop new diagnostic and therapeutic tools and identify new ways to design and produce improved glycoprotein drugs.

### CMEC - Center for Macroecology, Evolution and Climate

About: Integrates terrestrial and marine research in a cross-disciplinary research program addressing fundamental questions on the origin, maintenance, conservation and future of biological diversity on Earth.

# **Center for Geogenetics**

About: Studies ancient DNA, using whole-genome sequencing to extract the maximum information from study samples from genomes to epigenomes, pathogens and environmental metagenomes.

# **Center for Epigenetics**

About: Aims to gain better insight into how epigenetic regulation occurs on molecular and cellular levels and strives to relate the research to understand disease development and thus also to develop new types of prevention, diagnosis, and treatment. Other participants: University of Southern Denmark

### *Rigshospitalet:*

### **PERSIMUNE – Center for Personalised** Medicine of Infectious Complications in **Immune Deficiency**

About: The multidisciplinary centre works from the hypothesis that across patients with impaired immune function, there is a common pattern of un-discovered risk factors explaining the variation in risk of infectious complications. The centre aims at understanding the mechanisms explaining the variation in risk, and will from that formulate a series of immunodeficiency indices encapsulating the variation in risk for infectious complications. The indices will be used to personalise interventions aimed at reducing infectious complications.

### The Danish Cancer Society / Kraftens Bekampelse: CARD – Center for Autophagy, Recycling and Disease

About: The main ambition is to elucidate the orchestration of cellular energy balance, damage control, recycling and autophagy with focus on the regulation of autophagy and lysosomal integrity and their crosstalk with other cellular processes.

#### The State Serum Institute **CVIVA – Center for Vitamins and Vaccines**

About: Aims to document that vaccines and vitamins effect the immune system in a much more general way than previously thought.

### **NOVO NORDISK FOUNDATION'S RESEARCH CENTRES:**

### Technical University of Denmark: Novo Nordisk Foundation Center for **Biosustainability**

About: A transdisciplinary research centre in biobased sustainability whose goal is to create new knowledge and technology that can drive the transition of the oil-based chemicals industry to more sustainable, biobased production, where chemicals are instead produced with the aid of highly specialised cell cultures - so-called cell factories. International sections: University of California, San Diego, USA; Chalmers University of Technology, Sweden; KTH – Royal Institute of Technology, Sweden; University of Copenhagen, Denmark

#### University of Copenhagen: Novo Nordisk Foundation Center for **Basic Metabolic Research**

About: The Centre's goal is to understand the causes of diabetes and obesity by performing research on the molecular mechanisms underlying development of these diseases.

Alliances: Consorci Institut D'Investigacions Biomèdiques August Pi in Sunyer, France; Institut National de la Recherche Agronomique, France; Leiden University, Holland; Karolinska Institute, Sweden; University of Massachusetts Medical School, USA; University of Gothenburg, Sweden; BGI (Beijing Genomics Institute), China; Joslin Diabetes Center, Harvard Medical School, USA

### Novo Nordisk Foundation Center for **Protein Research**

About: The Center comprises a wide range of expertise and skills within its research programs spanning disease systems biology, proteomics, high-throughput protein production and characterisation, chemical biology, disease biology, and protein therapeutics.

### Novo Nordisk Foundation Section for **Basic Stem Cell Biology**

About: The section performs basic research within developmental, stem cell and molecular biology with the goal to produce knowledge that will be a foundation for new, more focused and effective treatment methods for diabetes and cancer, respectively.

### The State Serum Institute: **Danish National Biobank**

About: The Danish National Biobank at the State Serum Institute provides researchers with a comprehensive view of and access to millions of biological samples from the Danish healthcare system. It will also be possible to link the samples to information in the national registers.

### **OTHER FOUNDATIONS**

Many other private Danish and Swedish foundations have contributed to establishing research centres or supporting research in the region, such as the foundations Lundbeckfonden, Villum Fonden and the A.P. Møller Foundation in Denmark, and the Wallenberg Foundations and the Crafoord Foundation in Sweden. Several examples of research centres that have received support from some of these actors are The Lundbeck Foundation Center for Integrated Molecular Brain Imaging (CIMBI), where e.g. the Technical University of Denmark, the University of Copenhagen and Rigshospitalet are involved, as well as the Wallenberg Centre for Molecular Medicine at Lund University.

# MORE GROUPS AND CENTRES

There are also research environments and research centres in the region with a smaller-scale relation to life science. At Lund University for example there are the following strategic research areas: Nano-Lund (material science, nanostructures and their applications), BECC (the effects of climate change), MERGE (developing a multidisciplinary climate/ Earth System modelling node), Sustainable Production Initiative (creating a higher level of sustainability) and eLLIIT (IT and mobile communications). The same applies to the following Linnaeus environments at Lund University: Thinking in Time (cognition, communication and learning), LUCID (integration of social and natural dimensions of sustainability) and LUCCI (studies of carbon cycle and climate interaction).



# ESS AND MAX IV - Regional initiatives to grant researchers and businesses access to the facilities

LINX and Linxs: two projects with similar names. Both will inform and give access to the internationally unique materials research facilities ESS and MAX IV in Lund. But while Danish LINX concentrates on the business side, Swedish Linxs focuses primarily on promoting research.

The synchrotron light facility MAX IV, which was inaugurated in June of 2016, and the neutron research facility ESS, which will open for research in 2023, will create new and expanded opportunities for life science research in the Medicon Valley area. At the facilities, it will be possible to study biological matter and life processes in new and more advanced ways; this will include areas such as structural biology, medical imaging and the development of materials that assist in the body's absorption of pharmaceuticals.

There are already a number of projects and initiatives dedicated to helping the region's educational institutions and businesses exploit the potential that the globally leading research facilities will offer.



# LINX – LINKING INDUSTRY TO NEUTRONS AND X-RAYS

- A Danish venture with focus on the industry

The Danish project LINX represents a portal created collaboratively by the University of Copenhagen, the Technical University of Denmark (DTU), and Aarhus University to help the industry take advantage of the new possibilities to which the materials research facilities ESS and MAX IV in Lund and European XFEL in Hamburg will give rise.

The project consists of four parts:

- LINX Projects, where various projects are undertaken as cooperative efforts by industry and university partners.

- LINX Library, which will give businesses the right information about the technology that will be used at the facilities, as well as answer questions.

- LINX Academy, offering various types of customised training for businesses.

- LINX Facilities, to help businesses gain access to the appropriate facility for the research they wish to perform. For example, it is possible to collaborate with a university and access the facility free of charge if the research results will be published for general access and used openly, or to pay for access and reserve the option to keep the research results undisclosed.

Furthermore, based in part on the questions raised by the businesses and in collaboration with them, the universities will perform research within the six areas: Colloid materials, Drug discovery, protein-based pharmaceuticals and protein engineering, Sorption of liquids and humidity, Fiber structure and dynamics, Materials in operating and processing conditions, and Quality assurance. A small portion of the universities' project budget has also been allotted to performing small-scale pre-studies for businesses.

- Basic research will still be performed, just as it always has, but in Denmark there is a strong political demand to involve businesses at an earlier stage. That doesn't mean that basic research will only be performed in areas defined by the industry, but businesses will be involved in prioritising the areas that should be researched first, says the director of LINX Jimmy Binderup Andersen.

The project will also mean closer collaboration between universities, although they will retain their respective competence areas. DTU will focus primarily on imaging, the University of Copenhagen on small-angle scattering, and Aarhus University on powder diffraction. Businesses that contact Linx will be referred to the research team whose work corresponds closest to the area in question and the projects will be systematised to create the greatest value possible.

In addition to the University of Copenhagen, DTU, and Aarhus University, the Capital Region of Denmark, the Central Denmark Region, the Confederation of Danish Industries (DI), and a number of other companies are also participating in the five-year project, which began in early 2016. Among the company members are e.g. Novo Nordisk, Novozymes, BioModics and Xnovotech. There is also Swedish cooperation by Tetrapak, and according to Jimmy Binderup Andersen, Lund University has also shown interest in getting involved.

LINX has a total budget of eleven million Euros, and it is financed by the industry, as well as Innovation Fund Denmark.

### THE LINXS PROJECT

### - A Swedish initiative to establish a research institute

The project Linxs aims to invite top international researchers to undertake research of the methods used at ESS and MAX IV, as well as to develop new methods in the hopes of increasing the region's attractiveness whilst also marketing it all over the globe. Linxs also seeks to educate local researchers in how to utilise the two research facilities. The initiative is still in its early stages, but the objective is to receive a donation, for example from a foundation, large enough to establish an institute between ESS and MAX IV that will help researchers globally and locally to utilise the new resources.

- We can't create a university chair for everyone we'd like to have here, or force companies to relocate to the area. So we invite them to come and work on something useful that we need help with. If we invite a professor from Cambridge, for example, the issue is not a monetary one, but rather that the person in question can concentrate on research, says project manager Martin Stankovski. Linxs focuses on three broad areas of research: soft matter, life science, and hard matter. At the moment, emphasis is only being placed on the research aspect, but it is possible that businesses will be involved in the future.

So far, Linxs is a completely Swedish project, run by Lund University, but members of the international Scientific Advisory Board include e.g. Lise Arleth, Professor of Experimental Biophysics at the Niels Bohr Institute at the University of Copenhagen.

According to Martin Stankovski, those who have made larger donations will be able to name the institute projected to result from the three-year project Linxs, which began in early 2016. The plan is to incorporate the institute into Science Village Scandinavia, where it will preferably have its own premises near ESS and MAX IV in the Brunnshög area, and turn over between 16 and 24 million Swedish crowns annually.

### **OTHER INITIATIVES**

There are a number of other initiatives aimed at exploiting the potential of ESS and MAX IV. They include:

#### Cross Border Science and Society

An Interreg-project with 27 Swedish, Danish and Norwegian partners and a total budget of 19 million Euros that aims to take advantage of the possibilities that ESS and MAX IV will offer. Project partners include Aarhus University, Technical University of Denmark (DTU), the University of Copenhagen, Lund University, Malmö University, Chalmers, University of Gothenburg and the University of Oslo, as well as a large number of other organisations, regions, municipalities and authorities. The five component projects centre on Border-regional network and research programmes, International attractiveness, Regional supply base, Border obstacles and Welcoming international talents.

#### Strategy group for MAX IV and ESS

The group is based at the Faculty of Science at Lund University, and aims to support the faculty board with issues that pertain to the two research facilities. Among other things, the group can initiate or promote activities that will further the faculty's cooperation with and utilisation of MAX IV and ESS.

#### CoNeXT – Copenhagen University Neutron and X-ray Techniques

A project comprising all of the faculties at the University of Copenhagen with the exception of the Faculty of Theology. It aims to ensure that the university will be ready to use the full potential of the new neutron and X-ray sources in Lund and Hamburg, and that it can act as a portal for Danish and northern European Industries with potential for use of the research infrastructures.

#### DanScatt

An instrument centre for the Danish users of synchrotron- and neutron-sources as well as

free-electron X-ray lasers. DanScatt provides funding for travels to the research facilities and advises new users. Members of DanScatt include the University of Copenhagen, Aarhus University, DTU, University of Southern Denmark, Roskilde University, Aalborg University, Statens Serum Institut, Haldor Topsøe, Xnovo Technology ApS, and ESS Data Management and Software. It receives support from the Danish Agency for Science, Technology and Innovation.

#### Open Lab Skåne

A three-year project run by Biofilms – Research Center for Biointerfaces at Malmö University, the Department of Food Technology, Engineering and Nutrition at Lund University and SmiLe Incubator in Lund. The actors open up lab and office space for companies, which can then also learn to use the universities' equipment. The aim is to increase knowledge exchange and reduce the distance between industry and academia. The project is also directed at e.g. ESS and MAX IV.

**In addition**, there are many initiatives and projects on regional, national, and international scales to take advantage of the potential offered by ESS and MAX IV; among others, they are within the Swedish research institution Rise and at DTU.

Two international initiatives are **SINE2020** and **Baltic TRAM**. The former is an EU-funded project within Horizon2020 that will run from 2015-2019. The Industry Consultancy Initiative of SINE2020 invites applications from the industry for the use of European neutron sources for test measurements or feasibility studies free of charge.

Baltic TRAM is an international Interreg-project aimed at strengthening cooperation between analytical research institutes and companies by providing the industry with new kinds of access to expertise, research facilities and open science and innovation cloud concepts.

# HELENE HELLMARK KNUTSSON

Minister for Higher Education and Research in Sweden (Social Democrats)



Biopharma, bioinformatics and personalised medicine are important research and development areas emphasised by the Swedish Minister of Higher Education and Research Helene Hellmark Knutsson. The Swedish government is investing in e.g. collaboration between academic research and businesses in biopharma. The Minister has also highlighted the future potential of the research facilities ESS and MAX IV.

# What does life science research in Medicon Valley mean for Sweden?

Medicon Valley is recognised internationally as one of the strongest life science regions in Europe. There is leading research being done in areas such as cancer, diabetes, inflammation, neuroscience and diagnostics development. Obviously, the region is also very important for Sweden in terms of job opportunities and business activity.

### What is the development within life science research in Medicon Valley that you as a minister would like to see in the future, and what political efforts is the government working on to create or support that development?

We have made large investments in Scania in recent years. MAX IV and European Spallation Source, ESS, are world-class infrastructure projects, both of them with potential applications within life science. MAX IV is a synchrotron light facility that can be utilised within structural biology, and ESS will become a valuable tool for life science researchers in Sweden and internationally.

The government intends to continue prioritising these infrastructures, and investments that aim to increase their use, perhaps primarily by businesses, are recommended in the research proposition. It is hoped that the environment that surrounds the facilities will develop into an exciting innovation cluster and attract academic researchers as well as companies to the region.

# What overall areas within life science do you as a minister consider to be of particular importance for research in the future?

An area that the government has prioritised clearly is biopharmaceuticals. Manufacturing biopharma requires new technology and stabile conditions and infrastructure. In this respect, Sweden has advantages compared to many other countries; we have strong medical research in general, not least in protein research, where Sweden has been at the forefront for a long time.

Another area that we need to develop is bioinformatics. The new technologies being used in e.g. the life science sector generate large amounts of data that must be processed and analysed; the need for expertise in bioinformatics is enormous.

Yet another challenge is how to ensure that new knowledge is utilised as innovations and treatments in health care. Thanks to modern genomics and proteomics, treatments can be tailored on an individual level. Personalised medicine needs to be seen as one of the greatest potentials – and challenges – of the future.

Are there plans for new strategic research areas, directed funding for research or other directed research support that can impact life science research? In the recent parliamentary decision on the research and innovation proposition, the government expresses clearly what it will do to strengthen Sweden's opportunities to contribute to improved health, in Sweden and in the world. We invest in clinical research in collaboration with the health care sector, reinforce infrastructures and other resources for medical research and make investments in the cooperation between academic research and the business sector, particularly in biopharmaceuticals.

Investments in research in closely related areas will also be able to benefit the life science sector, as will research in antibiotics resistance and research in welfare, social services and work life. Five cooperative programmes were recently launched, one of which is life science. Within the parameters of these cooperative programmes, we intend to – through Vinnova – invest 400 million Swedish crowns in strategic innovation areas.

# Are there upcoming large investments in life science research in Sweden that you can tell us about?

We recently signed an agreement with the USA for expanded cooperation in the area of cancer. Furthermore, the government is working to make Sweden the new host country for the European Medicines Agency, EMA. We believe that Sweden has a lot to contribute as a host country, not least competence within life science. We also have a very competent national authority, the Swedish Medical Products Agency, that is highly respected in Europe, which is a strength.

What is your view on Sweden's two large life science clusters: Stockholm-Uppsala and Medicon Valley, respectively? Which is most important for Sweden, how can they complement each other, and what tan-

### gible plans are there for investments in the future?

Both of these clusters are incredibly important for Sweden, of course. It is encouraging that both managed the "legacy of AstraZeneca" so well and harnessed the competence that remained behind when AstraZeneca chose to move some of its activities out of the respective regions.

I think that there are good opportunities for these clusters to develop further and grow stronger, and I see no reason to put them in opposition to one another. Sweden is a small country and there are many reasons for us to cooperate more extensively on a national level rather than compete on a regional level. That's why it is so valuable that there are now national initiatives underway in a number of areas, such as within biobanks, cell therapy and whole genome sequencing for clinical diagnostics in health care.

What is your view on the level of the life science research performed at Swedish universities with respect to other Scandinavian countries and in the world? Sweden stands up well in international comparisons. Karolinska Institute is, at sixth place, the only Scandinavian university to place in the top 25 in the 2017 ranking of the best universities for medical research and life science by QS World University Rankings; which is best in the EU after Brexit. If you look at the top 100 on that same list, you see that both Uppsala University (49) and Lund University (88) qualify. Swedish medical research was ranked number 13 in the world in 2015 for citations (Scimago Journal and Country rank).

# SØREN PIND

#### Minister of Higher Education and Science in Denmark (Venstre)

Denmark's Minister of Higher Education and Science Søren Pind was given an opportunity to respond to questions about Danish research politics affecting life science. He declined however, in part because the Danish government is currently developing a growth plan after having received recommendations from the Growth Team for Life Science on how Danish life science can become world-class, improve people's quality of life and contribute significantly to the Danish economy. (See more on page 43).



The research world is international, and a number of universities in the region are working actively to recruit excellent researchers from other parts of the world. Providing support in the process are the national tax relief schemes, the Danish version of which is more advantageous than the Swedish. Students from abroad - not least research students - are in great demand, and in the study year 2015/16 there were 3 253 international students at universities in the region.

that deals with the tax relief

The number of international

ces in Medicon Valley was

1 132 in the study year

• According to an evaluation

carried out by the Swedish

Higher Education Authority

government, tuition fees have

entailed fewer international

on behalf of the Swedish

were approved.

2015/16.

- Denmark and Sweden both offer special tax schemes for foreign employees, aimed to facilitate the recruitment of highly qualified international employees. The Danish system is distinctly more advantageous, which is apparent in statistics that show how often it is used.
- In 2015, the Danish tax scheme was used 5 494 times: of these, 2 483 were researchers, according to preliminary statistics from the Danish Ministry of Taxation, while in 2016, 838 applications

were made to the commission students from countries outside of the EU/EEA, and the scheme in Sweden. Forskarfees have also had a negative skattenämnden; of these, 589 impact on recruitment to research programmes. The report also shows that the number of paying female students had PhD students in the life sciendropped to 40% in the study year 2015/16 since tuition fees

were introduced.

• While Denmark also requires students from countries outside the EU/EEA to pay tuition fees, the system was already introduced in the early 00's and does not affect the statistics of recent years.

# INTERNATIONAL RESEARCHERS

International researchers play an important role for the region's universities. The University of Copenhagen and others work specifically to recruit outstanding researchers from abroad. Denmark and Sweden both offer special tax schemes for foreign employees, aimed to facilitate the recruitment of highly qualified international employees. The Danish system is distinctly more advantageous, which is apparent in statistics that show how often it is used.

The recruitment of highly trained workers to the life science sector takes place both nationally and internationally, particularly for the recruitment of researchers and for management positions. Whether or not foreign talents can be enticed depends on the interplay between the attractiveness of the workplace, the financial incentives, and the allure of the region as a place to live.

To improve their odds, Denmark introduced a special tax scheme for foreign employees in 1992, and Sweden followed suit in 2001. Particularly favourable taxation schemes for foreign talents can be an important tool when seeking to attract talents to two countries where there are - from an international perspective - returns that are considered low, a high tax rate, and a high cost of living. In Denmark, the scheme is used as an active instrument in the global race to attract highly qualified workers, whilst in Sweden, it was introduced mostly as a gesture, so as not to appear less attractive than neighbouring countries, which already had tax schemes for experts.

The Swedish scheme is not nearly as attractive, and nor is it utilised as often as its Danish counterpart. While a key employee in the Danish scheme needs

ATTRACTING AND **KEEPING TALENT:** Bringing the world to the universities of **Medicon Valley** 



to earn a minimum of 63 700 Danish crowns per month including employee benefits, a foreign expert in Sweden needs a monthly salary of 89 600 Swedish crowns to be approved. In 2015, the Danish tax scheme was used 5 494 times; of these, 2 483 were researchers, according to preliminary statistics from the Danish Ministry of Taxation, while in 2016, 838 applications were made to the commission that deals with the tax relief scheme in Sweden, Forskarskattenämnden; of these, 589 were approved.

The configuration of the two schemes entails that the Danish scheme can be used to attract Danes who have been working abroad for several years to a Danish workplace, whilst the Swedish system can only be used by non-Swedes. Additionally, the Danish scheme does not require the employee to reside in Denmark; s/he may also reside in a neighbouring country. That provides Medicon Valley with unique possibilities, as the combination of a high salary on the Danish side and a lower cost of living on the Swedish side can be a further financial incentive in the recruitment process. It is also an advantage that can be used to attract workers from Sweden's other life science clusters to Medicon Valley.

The salary requirement in the Swedish tax scheme is quite high, and it is believed that many companies

recruit employees from abroad without using the tax scheme. Thus, the statistics for applications for the Swedish tax scheme do not provide a complete picture of the number of international researchers and key employees in Sweden, whilst Danish statistics provide a more accurate representation. The number of foreign talents employed in Medicon Valley who use the tax schemes cannot be extracted from the statistics.

For the industry, another aspect is that the rate at which graduates and researchers are produced at domestic universities is not sufficient to supply the life science sector with highly qualified workers, who thus must be recruited from abroad. In Medicon Valley's six large life science municipalities (Gladsaxe, Ballerup, Copenhagen, Kalundborg, Hillerød, Gentofte), the number of foreign employees - both with and without a higher education - rose by 188% between 2008 and 2016, according to statistics from the Danish Agency for Labour Market and Recruitment. Since life science companies provide employment for between 41% (Copenhagen) and 71% (Gentofte) of the employees in the industry in their municipalities, statistics show clearly that there is a great need for foreign employees in the life science industry.

It is not possible to connect the work tasks or education of foreign workers in the statistics. There are no comparable statistics for Sweden.



# DENMARK

#### 'Tax relief scheme

The special tax scheme for foreign researchers and key personnel, widely known as the tax relief scheme, took effect in 1992 and has since changed several times, most recently in 2015; it was relaxed somewhat when the minimum monthly salary was reduced by 10 000 DKK.

#### Who can use the tax scheme?

Foreign researchers and key personnel employed in a Danish company or at a Danish research institution. Researchers are required to have at least a PhD-level education, and key personnel in the fiscal year 2016 were required to have a monthly salary of at least 63 700 DKK (salary incl. employee benefits).

#### Configuration

The tax scheme for foreign employees is a tax scheme with a taxation rate of 26%, which corresponds to a total tax rate of 31.92 including labour market contributions. Documented expenses for social contributions abroad and foreign social security contributions are the only deductions possible.

#### Conditions

The foreign employee is not

run an independent business in Denmark or received pension from Denmark in the ten years prior. Furthermore, the employee is not permitted to have been part of the management, or have had control or a significant influence on the company where s/he is to be employed in the five most recent years prior.

permitted to have worked or

#### Time limit

The tax scheme can be used for a maximum of five years.

### **SWEDEN**

#### Tax relief scheme

The tax relief regulations for foreign employees were introduced in 2001 and were most recently review in 2012 to include everyone whose earnings are over a set amount.

#### Who can use the tax scheme?

Foreign researchers, company managers, experts or other key employees employed in a Swedish company or a Swedish research institution. To take advantage of the tax scheme, it must be extremely difficult to recruit employees in Sweden with the required skills.

#### Configuration

Tax relief for foreign employees is such that only 75 per cent of the salary paid by the employer is taxed. The employer's compensation for expenses related to moving to and from Sweden, children's schools and similar, as well as two annual trips to the country of origin for the foreign employee and her family are also exempt from taxes.

#### Conditions

The foreign employee may not be a Swedish citizen or have lived in or resided permanently in Sweden within the past 5 years. The employer must be based in Sweden or be a foreign company with a permanent location for operations in Sweden. If these conditions are fulfilled and the foreign employee's monthly salary fulfils the condition of being higher than twice the price basic amount, the employee can be approved. In 2017, that amount is equal to a monthly salary of at least 89 600 SEK, including compensation for employee benefits.

#### Time limit

The tax relief scheme is valid for the first three years, and the intention should be to remain in Sweden for a maximum of five years.

# ABOUT THE FIGURES

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.

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# **INTERNATIONAL STUDENTS**

Attracting international students – especially research students – to the Medicon Valley area is one of the most important goals for the region's public and academic sectors. Universities and colleges spotlight the number of international research students as something positive; the goal of the Copenhagen Capacity's Talent Attraction project, which ran from 2012–2015, was to attract more international students and keep them in the region even after their studies were complete. On the whole, the number of life science students in the Medicon Valley area has increased in recent years, totalling 3 253 in the study year 2015/16. The increase has primarily been in Denmark however, and a report from the Swedish Higher Education Authority shows that the introduction of tuition fees for students from countries outside of the EU/EEA has negatively impacted the recruitment of research students from abroad.

A total of 3 253 international students were studying in life science programmes in Medicon Valley in the study year 2015/16; of them, 1 132 were PhD students. 1 078 of the 3 253 international students – 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 Scania.

The number of international life science students in the Medicon Valley area has increased 63% since 2008, due to an increase in international life science students in the Capital Region of Denmark. While Denmark had 82% more international life science students in the study year 2015/6, the number has decreased in Sweden since 2010, which can be explained by the introduction of tuition fees in 2011 for foreign students from outside of the EU/EEA who are not part of an exchange programme. Since then, the number of international students in Sweden has decreased. According to an evaluation carried out by the Swedish Higher Education Authority on behalf of the Swedish government, tuition fees have entailed fewer international students from countries outside of the EU/EEA, and the fees have also had a negative impact on recruitment to research programmes. The report, which was presented in early 2017, also shows that the number of paying female students had dropped to 40% in the academic year 2015/16 since tuition fees were introduced.

While Denmark also requires students from countries outside the EU/EEA to pay tuition fees, the system was already introduced in the early 00's and does not affect the statistics of recent years.

Generally speaking, Lund University is the Swedish university at which the largest number of international students begin a programme or a course. However, if one looks exclusively at life science



programmes, there are more international students in Stockholm as well as in Uppsala than in Scania.

Because of the structure of the Swedish educational system, which allows students to take individual courses at the universities, the total number of students is significantly higher than in Denmark. For example, if a student is registered for two single courses at two different educational institutions in the same semester, s/he will be accounted for twice in the statistics. Thus, it is impossible to make a direct comparison of Danish and Swedish education statistics, and the figures presented in this section should be interpreted with that in mind.

# NUMBER OF INTERNATIONAL STUDENTS IN THE STUDY YEAR 2015/16

		of whom in research	
	Number of students	programmes	Change 2008/09 - 2015/16
Skåne	1 078	332	18%
Stockholm-Uppsala region	3 613	1 589	25%
Västra Götaland	832	243	6%
Sweden, rest of	1 747	319	16%
Sweden	7 270	2 483	19%
Eastern Denmark	2 175	800	99%
Denmark, rest of	1 562	317	64%
Denmark	3 737	1 117	82%

Source: Customised analysis from Statistics Denmark and Statistics Sweden

# ABOUT THE FIGURES

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 registered 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.

Above all else, the strength of Medicon Valley lies in its strong niche positions. That goes for companies like Novo Nordisk, but also for university research, where more narrow research areas such as genomics and sports medicine at the University of Copenhagen and coagulation research in Lund are internationally prominent, and a small but specialised university like the Swedish University of Agricultural Sciences in Alnarp features high on global ranking lists. According to its representatives, a success factor for the University of Copenhagen has been the small elite research environments that have been intentionally built up over the past decade. The hopes for the future are also increasing in a region that is anticipating the research to come at the facilities ESS and MAX IV.

such as the Novo Nordisk

ESS and MAX IV, which will

processes in new and more

generate greater exchange

with international researchers.

Copenhagen.

 In the international competition where American and British universities are attracting the best researchers, strong research in specialised areas is an opportunity that the universities in Medicon Valley are prepared to seize. That goes for entire universities like the Swedish University of Agricultural Sciences in Alnarp and the Technical University of Denmark - and more specialised research areas and centres

 Representatives from Danish Foundation Center for Protein universities want to see Research at the University of more collaboration between Swedish and Danish universities. Not only does it mean • There are high hopes hung on the advantage that comes the materials research facilities from sharing experience and a greater number of collaboratimake it possible to for example ve partners in the region, but it study biological matter and life also defines more clearly how research can complement, rather than compete with, the advanced ways, and potentially

universities.

research being done at other

# STRONG SPECIALISED AREAS BOOST **RESEARCH IN MEDICON VALLEY**

Nine universities with research in the life sciences - five on the Danish side and four on the Swedish side of the Øresund Strait. Nearly 7 000 university researchers in the area and still more at the university hospitals, state institutions and organisations. Over 8 000 peer-reviewed articles published by university researchers in the life sciences in 2015. Medicon Valley is a thriving region for research, but seen internationally, it is still a notch below the absolute highest-rate research areas. However, there is strength in the region's niche areas.

One important way to reinforce a region's research is to attract outstanding researchers from around the world. On that particular front, the conditions in the Medicon Valley area aren't quite as good as those at the large American and British universities, where the language and lucrative regulations have facilitated recruitment for a long time.

Another difference that Kristian Helin, Vice Dean of Research at the University of Copenhagen's Faculty of Health and Medical Sciences, points out is that the large American universities have been

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able to focus on being elite research universities, admitting only the very best students from America and abroad, whilst the large Danish and Swedish universities have a broader assignment and need to encompass their entire respective countries.

Novo Nordisk's Vice President for R&D Academic Partnerships Uli Stilz estimates that the Copenhagen region is among the world's top 50 life science clusters. He believes that the region's research is outstanding in a number of areas, with Novo Nordisk collaborating closely both with Danish and Swedish

when it comes to exploring new science but also specialised elite research environments over the training and attracting talent. At the same time Novo past decade. In addition, the university has worked Nordisk collaborates with universities and academic hard to recruit successful researchers, gladly with an centers globally, with excellence in a given area being international background. the main driver to choose the partners. Quite naturally the majority of research collaborations are therefore Another way to reinforce the region would be to invest still more in its successful areas of particular Furthermore, Uli Stilz asserts that European unistrength, according to Uli Stilz. His employer, Novo Nordisk, is itself an example of a company within versities are generally not as well positioned as Amea strong therapeutic focus "Another way to that has grown from its local companies, as the venture capital reinforce the regiposition in a small country to a global leadership posi-

strongly focussed on academia-industry collaborations as a discoveries. He also points out that in many European countries

anchored internationally.

rican universities at exporting

their research results in spinoff

markets are less well developed

Universities have a broader education mandate with teaching and supportive administrative tasks taking a larger share of faculty responsibilities. In contrast, in particular elite American Universities are very selective in student enrolment and provide an excellent research environment with a competitive advantage to attract international researchers.

Universities. The regional universities in the Greater

Copenhagen area are a vital partner for Novo Nordisk

When it comes to the latter, it would seem that things look better in Denmark than in Sweden. According to the Swedish report "Meeting the Challenges of Higher Education", published in 2016 by the Institute for Evaluation of Labour Market and Education Policy (IFAU), Swedish researchers have less time for research than Danish. The difference is particularly great for associate professors and less for professors - but it is still noticeable.

and Europe historically has more on would be to invest still more in its path to industrialize basic science successful areas of particular strength."

tion. Diabetes and metabolic diseases are also a large and important research area in Medicon Valley, where there is a symbiotic relationship between research and industry

- not least because Novo Nordisk invests in life science research at the region's universities through its foundation. The Novo Nordisk Foundation is behind e.g. The Novo Nordisk Foundation Center for Protein Research and The Novo Nordisk Foundation Center for Basic Metabolic Research at the University of Copenhagen, both of which are strong research environments.

According to Kristian Helin, the University of

Copenhagen has also invested in establishing more

This survey of life science research in Medicon Valley shows that the University of Copenhagen is clearly the largest actor in all areas. The university has the most comprehensive and successful research in the field, and ranks comparatively high on international ranking lists. It is followed by Lund University, likewise a large university that places in

# **DEFINITION OF THE LIFE SCIENCES**

There is no exact definition of which subject areas comprise the life sciences.

The definition that has been used for this report and in contact with the universities is the following: "the basic research and the applied research that are significant for the life science organizations in the region, in a broad sense. It is preferable to include too much rather than too little in the umbrella term 'life science'." Furthermore, Medicon Valley Alliance's broader definition has been used: "Life science can be defined as the study of living organisms (including microorganisms, plants, animals and human beings),

but when describing a life science cluster, life science is perceived in a broader context. It includes the pharmaceutical, biotechnological and medical technology industries, as well as the academic institutions conducting research within life science and hospitals treating patients in the clinic."

The following, more concrete delineation was used in data compilation: "works/studies at departments/ faculties of medicine and health sciences, biology, chemistry, food sciences and other departments/ faculties, where a minimum of 50% of the research conducted is within the life sciences."



Obstetrics and gynaecology are two of the strongest areas in the Danish part of Greater Copenhagen when it comes to the life sciences, according to the DTU report "Life science under mikroskop" (Life Science under the Lens). There are also successful researchers in the field in Scania. Among

the top 100 on most ranking lists. The Technical University of Denmark (DTU), which is more specialised in engineering, is currently investing in an expansion of its life science research. The Swedish University of Agricultural Sciences (SLU) in Alnarp has its niche in agriculture and plant research, and taking its size into consideration, it can be considered internationally successful.

Among the region's smaller universities, Malmö University conducts the most research in the life sciences, with a dental health education programme and e.g. research in biofilms and biobarriers.

The life science research at Roskilde University includes for example green chemistry and enzymes, whilst health sciences are an import research area at Kristianstad University. Aalborg University in Copenhagen has a campus in Copenhagen where research is done in biorefinery and non-coding RNA and RNA therapeutics. The National Institute of Public Health, which is officially part of the University of Southern Denmark but is located in Copenhagen, has a national mission in public health research.

The University of Copenhagen is by far the region's largest university, and employs more than half of

other projects, there is the Danish-Swedish collaboration Reprounion, which brings together 13 clinical and research units in the region, Medicon Valley Alliance and Ferring Pharmaceuticals. Their goal is to create a multidisciplinary research centre for reproductive medicine.

the total number of the life science researchers at the region's universities - more than 4 000 of nearly 7 000 researchers. Thus, the region's largest research areas correspond to a great extent to the areas that are largest at the University of Copenhagen. In addition to diabetes and metabolic diseases, which were mentioned above, these include cancer, protein research, research in genetics, DNA and RNA, plant research and stem cell research. Neuroscience is also a growing area that was previously largest at Lund University, but the University of Copenhagen is also focusing its efforts there.

Parallel to that, the University of Copenhagen has long since had flourishing research in sports medicine, an area within which Lund University is also becoming stronger.

Another area of research at many of the region's learning institutions - including DTU, Lund University, SLU in Alnarp, Roskilde University and Aalborg University in Copenhagen - is the use of biobased raw materials for biobased products, pharmaceuticals or fuel.

There are also a number of research areas that rate strongly in international comparisons although they do not employ as many researchers in the

region. Among them are pharmacy research - which concerns the development of new medicine - at the University of Copenhagen, and coagulation research at Lund University. The research on chemical ecology at the Swedish University of Agricultural Sciences is thriving, although it is not very wide-ranging.

The region's large and thriving areas are not necessa-

rily the largest in international comparisons, however. In the report "Danish Life Science Group investigated on behalf of DTU how the Copenhagen region – excluding Scania but including clinical research at the hospitals of the Capital Region of Denmark and Region Zealand – measure up

in a comparison with ten other outstanding life science regions in the world. Based on data about the number of articles and citations with respect to the averages for each subject area, the authors of the report determined that the region has four definite and five potential areas of strength, all of which are within the medical sciences.

The definite areas are:

- Medical biochemistry
- Dermatology
- Obstetrics and gynaecology
- Reproductive medicine (fertility treatment etc.) And the potential areas are:



"Throughout the under the Lens" from 2017, Iris region, the belief is strong that ESS and MAX IV will fortify research in e.g.

structural biology."

- General veterinary science - Pharmaceutical science

- Rehabilitation

- Anaesthesiology and pain medication - Pulmonary and respiratory medicine

In terms of the life science research in the world, these subject areas comprise five per cent, which is a lower figure than for many of the other geographic areas in the comparison.

However, as Uli Stilz from Novo Nordisk and others have pointed out, there is potential in locating more specialised, niche areas for the universities in the Medicon Valley area. The Swedish University of Agricultural Sciences in Alnarp is a good example of the value of concentrating an institution's efforts

on a more defined area. Although the university is significantly smaller than the University of Copenhagen and Lund University, it ranks number four in the world within its area of focus, Agriculture and Forestry, on the QS World University Ranking, and ninth in the world among small universities in Times Higher Education's ranking The World's Best Small Universities 2017.

Another, more concrete niche to develop – on which the Swedish government also focused in its most recent research proposition - is bioinformatics research. Since there is access to comprehensive and well-organised statistics and large biobanks in the Scandinavian countries, the conditions are very favourable.

The area in which the highest expectations on the region's future research are mounting is another, however. The large, international materials research facilities ESS and MAX IV in Lund, which will be the most advanced in the world in neutron and synchrotron light research, respectively, will entail great opportunities for life science research. MAX IV was inaugurated in the summer of 2016, but according to plan, work is still being done on the beamlines and experiment set-ups, which are not quite complete. ESS will be inaugurated in 2023. Throughout the region, the belief is strong that the research facilities will fortify research in e.g. structural biology. Despite - or rather, owing to - their international nature, which means that local researchers will compete on equal terms with researchers from all over the world for research time at the facilities, it is anticipated that greater numbers of

international researchers will come to the Medicon Valley area, and can collaborate with and inspire those already working in the region. That awareness of the potential of ESS and MAX IV has spread is plainly evident in the number of projects and initiatives started to ensure that local and regional researchers and businesses will be able to exploit the potentials of the two research facilities to the fullest. (Read more on page 49.)

ESS and MAX IV also balance out the Danish and Swedish parts of Medicon Valley to a degree. As eastern Denmark is a capital region and the location of the region's largest and most successful university, there is a clear emphasis on the Danish side of the Øresund. The two facilities' placement just north of Lund offsets that somewhat.

Denmark has also made significant investments in both ESS and MAX IV, however. ESS' data centre has been placed in Copenhagen, as Denmark and Sweden are both host countries for ESS, and Danish collaboration at MAX IV comprises e.g. the beamline DanMAX.

In a broader research perspective, it is clear that the learning institutions on the Swedish side are aware of the collaborations with the larger University of Copenhagen, and like to emphasise them - the same is true of all of the universities on the Swedish side of the Strait. The University of Copenhagen on the other hand prefers to look outward, emphasising its international collaborations and membership in exclusive research networks such as IARU, the International Alliance of Research Universities.

Representatives of the University of Copenhagen are, however, calling for increased collaboration over the Øresund. Among other things, Morten Pejrup, Vice Dean of Research at the Faculty of Science at the University of Copenhagen, would like to see better incentives for the creation of Swedish-Danish research projects and -environments. There is also potential for the region in that wish, where - with the exception of several distinct areas - Swedish-Danish local research collaborations are not particularly comprehensive today. If knowledge of the other learning institutions in the region increases - and in extension, also contact – the advantage will be a greater exchange of experience and more potential collaborative partners in the region, and it will also become clearer how research at each university and in each group can find its own niche and complement the work being done elsewhere, both regionally and nationally, rather than compete with it.

# **ABOUT THIS REPORT**

This report is intended as a survey of life science research in the Medicon Valley region, its strengths and its potential. The work has largely involved extracting previously unknown data, as the term "life science" overlaps the traditional distinctions made in the university world. Although transdisciplinarity is becoming more common and popular, university statistics generally adhere to the classic faculty- and department divisions. However, research in the life sciences is conducted within medicine, science and engineering, and sometimes even in the social sciences. Sometimes the entirety of a department's research can be classified as life science, and sometimes only parts.

Determining which researchers and subject areas the life science umbrella term should comprise has required that the learning institutions perform new calculations and evaluations. It is a time-consuming task, and time is often in high demand. However, life science is considered more and more important for society, not least when politicians are investing greater resources in strengthening research and the industry.

One concern is that there is no definitive definition of the term "life science". It clearly concerns the study of life, but the breadth of the definition depends on who is posing and answering the questions. The definition, or definitions, that has been used for this report are detailed in the fact box on page 62.

The information contained in this report has been primarily retrieved from the universities themselves, as well as from interviews with their representatives and researchers. The interviewees, with the exception of the cases in which mere background information was in question, are named within the articles.

Information about the number of researchers and students, as well as articles and citations, was gathered via a written guestionnaire that was sent to each university. The interviews have formed the foundation of the section of this report that deals with each university's areas of strength within the life sciences. All interviewees have had the opportunity to factcheck the text. Furthermore, all informants were given the opportunity to read the report before it went to print.

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- Formas
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Interviewees are identified in the articles.

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# **Behind the report - Medicon Valley Alliance:**

# THE FOLLOWING ORGANIZATIONS AND COMPANIES ARE CURRENTLY MEMBERS OF THE MVA 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 245 members, who together employ approximately 140.000 people, represents the region's triple helix and include universities, hospitals, human life science business, regional governments and service providers.



# 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.



# medicon valley alliance

**Creating Opportunities**