



Danmarks  
Grundforskningsfond  
Danish National  
Research Foundation



CURIOSITY  
PAYS  
OFF

DANISH NATIONAL  
RESEARCH FOUNDATION

## SELECTED KEY NUMBERS FOR THE DANISH NATIONAL RESEARCH FOUNDATION

Patent applications submitted	2007	2008	2009	2010	2011
Public research institutions	131	128	129	122	171
DNRF share (number)	17	13	11	19	24
DNRF share (percent)	13	10	9	16	14

Patents granted	2007	2008	2009	2010	2011
Public research institutions	13	11	16	13	45
DNRF share (number)	6	1	2	4	7
DNRF share (percent)	46	9	13	31	16

Spin-outs	2007	2008	2009	2010	2011
Public research institutions	9	12	7	11	7
DNRF share (number)	2	1	2	1	1
DNRF share (per cent)	22	8	29	9	14

Source: Commercialization statistics 2011 compared with data from annual reports from the centers.

The centers interface with other researchers and businesses in Denmark and abroad. The numbers in the right-hand column show the extent of the cooperation conducted by the 40 active centers in 2011.

# 1619

Researchers at foreign universities

# 417

Researchers at Danish universities

# 47

Foreign businesses

# 67

Danish businesses

Established in 1991, the Danish National Research Foundation is an independent foundation whose objective is to fund excellent research of international caliber. This mainly takes place through the Centers of Excellence program, under which excellent research communities may receive funding for up to ten years. The foundation provides annual grants of DKK 400 million (in 2008 DKK). Since granting the first funds in 1993, the foundation has created 88 Centers of Excellence and supported Danish research with more than DKK 6 billion.

# CONTENT

**05** Preface

---

**06** Fluorescent tubes may bring fresh fruit to Denmark

---

**10** Molecules can prevent cancer tumors from growing

---

**14** New technology prevents toxins from reaching plant seeds

---

**18** Combating the consequences of climate change

---

**22** One water sample is all it takes to determine the biodiversity in a lake or an ocean

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**26** Research - a matter of life or death

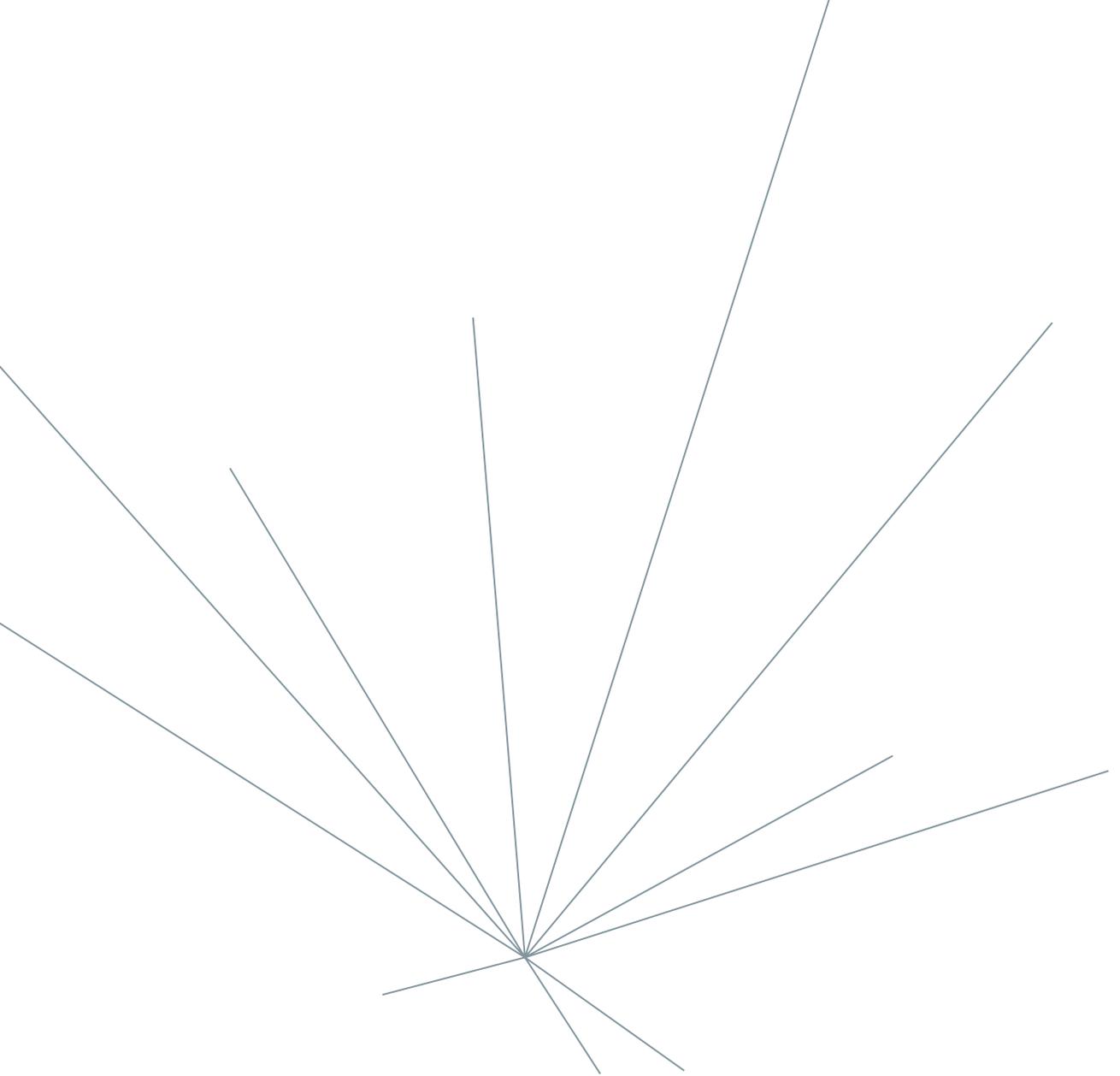
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**30** Frontier research gives new companies a unique advantage

---

**34** Textiles of the past inspire today's designers

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Frontier research and applied research complement each other and increasingly overlap. Our foundation uses words like "excellent," "frontier research," "highly ambitious" and "original" to describe the research we fund. The research must possess the potential to make breakthroughs, to advance scientific development and thus to help change the world. The foundation supports research propelled by desire, curiosity and wonder, and research conducted with dedication, focus and passion.

This has proved to be an excellent strategy. It pays to let preeminent researchers tackle the research issues that most ignite their interest. The Danish National Research Foundation has financed research whose significant findings have changed the face of science in the research areas concerned and whose application has made a difference in society.

The commercialization statistics for Danish research in 2010 showed that every sixth patent application submitted from a public research institution came from a DNRF Center of Excellence. This number exceeded the share one could expect when one considers that DNRF allocates approximately 2% of all public research funds. This demonstrates a substantial application potential, even though the foundation does not make this a criterion when selecting new centers or extending existing ones. The foundation solely considers scientific quality. We have awaited the new figures for 2011 with great anticipation to see whether this pattern repeated itself. Far more patent applications were submitted in 2011, of which DNRF centers account for an impressive 14%.

Both international and national statistics use patent applications, patents and spin-outs as commercialization indicators. The importance of these numbers is questionable, as they are often small and lump valuable patents together with less successful patents. They also fluctuate considerably from one year to the next. It is debatable whether the numbers suffice to elucidate the application activities in a given research community. Statements regarding research communities' partnership relations and more qualitative analyses would likely contribute to an increased understanding.

This publication looks behind some of the numbers and presents eight Centers of Excellence whose groundbreaking research has engendered a significant commercial activity. Although this also applies to many of our other centers, these eight have been chosen as the first in a series of examples in which the researchers themselves provide a perspective on the commercial applications of their research. Our Centers of Excellence receive support not only from the Danish National Research Foundation but also from other national and international sources. The frontier research ideas may be conceived before the center is established, and the research results may be transferred to actual commercial activities with the support of other sources than the DNRF.

Several of the stories in the following pages confirm the old adage that the future is indeed hard to predict. They tell a story of how research driven by an insatiable curiosity to understand the as-yet unexplainable has fostered applications no one could have foreseen.

For instance, research at the Center for GeoGenetics has gained international attention and changed the course of world history. Researchers at the center have developed technologies for analyzing ancient DNA, technologies that also led to the development of an entirely new monitoring tool capable of using a single sample of water to determine with extreme accuracy the variety and number of species in a lake or stream. This may become a tool for solving environmental problems and may eventually be used to develop fishing quotas, etc. In this way, research into the now extinct woolly rhinoceros may aid in conserving current animal species and ensuring sustainable commercial fishing.

Nor was it expected that research on processing massive data algorithmics could be used to deal with extreme weather situations in the future, as the story on pages 18-21 illustrates. SCALGO, a spin-out company from the Center for Massive Data Algorithmics, has assisted in developing a Flash Flood Mapping tool used as a key part of an emergency response system to plan new urban areas and ensure that sewer renovation and road water diversion are high priorities.

The research performed by the centers is not isolated from the society that surrounds them. Even though research activities are not chosen to solve specific social challenges, researchers are generally dedicated to and absorbed by the world around them - and they want to apply their knowledge. The story on pages 26-29 about research on vaccines and vitamins showcases results that have the potential to save thousands of human lives worldwide every day. Pages 14-17 describe how researchers have succeeded in removing toxins from edible plant parts.

Three of the stories deal with how the centers have produced actual spin-outs that are solely engaged in commercializing the centers' findings. The stories cover new workplaces, the hope of treating and curing illnesses and the joy of seeing how new knowledge can make a difference. These spin-outs are characterized by having been created on the basis of new and original knowledge.

The knowledge generated by the centers is not only applied when new businesses are established. The stories from the Center for Textile Research and the Center for Individual Nanoparticle Functionality tell how the centers cooperate with businesses as another means of spreading their knowledge.

From the foundation's perspective, the presence of many players is an absolute strength of the Danish research and innovation-funding system. Many instruments are required because the paths to success are many - both for research and for innovation. Unencumbered research that engenders new knowledge, better education, innovation and growth will serve to benefit culture and society in Denmark and the world.

Enjoy.

Thomas Sinkjær, Professor  
Director

Professor Liselotte Højgaard  
Chair, Board of Directors

06

FLUORESCENT TUBES  
MAY BRING  
FRESH FRUIT  
TO DENMARK



In the 1980s, research that had applications was practically considered uninteresting. Luckily, this attitude now belongs to the past.

IB CHORKENDORFF  
CENTER FOR INDIVIDUAL NANOPARTICLE FUNCTIONALITY (CINF)



# FLUORESCENT TUBES MAY BRING FRESH FRUIT TO DENMARK

Business cooperation plays a natural part in the daily work of the Center for Individual Nanoparticle Functionality, affording clear advantages to business and research communities alike.

The Center for Individual Nanoparticle Functionality (CINF) at the Technical University of Denmark has made commercialization and cooperation with industry integral parts of its day-to-day business. In the past five years alone, the center has submitted 14 patent applications, registered five inventions and generally worked continuously with various companies to develop catalysts. Researchers are intent on solving fundamental issues, but they always keep an eye on the possible applications of their work.

“When I graduated in the 1980s, research that had applications was practically considered uninteresting. Luckily, this attitude now belongs to the past,” explains center leader, Ib Chorkendorff.

### Ambitious goals

CINF’s long-term goal is to establish a fundamental understanding of how structure and catalytic activity relate at the molecular level. One of the center’s major ambitions is to develop an efficient method for decomposing water into oxygen and hydrogen solely by using sunlight. If successful, this will obviously have a far-reaching impact on how we solve the world’s energy problems. However, Ib Chorkendorff cannot be certain that this will ever become a reality.

“Nothing suggests that it is impossible,” he points out about this ambitious goal. “Nature has done it. So we are taking this avenue.”

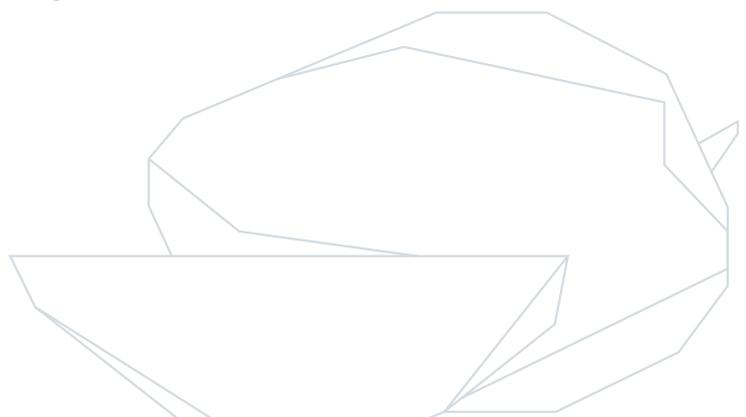
### Challenge-driven research

Even though the world’s overall energy problems remain unsolved, research from the center is already helping to find smart and green solutions.

A specific example is the center’s cooperation with Kjærulf Pedersen A/S to develop a catalyst that reduces the energy consumed when fresh fruit is transported across the globe.

Fruit transported over long distances must obviously reach supermarkets and consumers in good condition. The fruit is therefore typically transported in cooling containers that slow down the ripening process. However, fruits like pineapple, banana, avocado and papaya emit the gas ethylene, which works as a hormone that expedites and enhances ripening. To prevent the fruit from becoming over-ripe, the containers must be regularly ventilated and subsequently cooled down. This costs energy and money.

It was with an eye to solve this problem that Ib Chorkendorff was contacted by Kristian Ehrhorn, director of research at Kjærulf Pedersen A/S a few years ago. This marked the beginning of a close cooperation. During the past years, Kjærulf Pedersen A/S and CINF have collaborated on research to determine whether photo catalysis can be made efficient enough to become a cost-effective method of removing ethylene as the gas is created. Essentially, the method is extremely simple, requiring only an ordinary fluorescent tube – but without the usual fluorescent surfacing. This allows ultraviolet light from the tube to illuminate a small wad of glass wool covered with titanium dioxide, the same material used in white paint and sunscreen. When the material absorbs the light from the tube, the energy transforms the ethylene into harmless products such as CO<sub>2</sub> and water without any significant heating, the very factor to be avoided.



## The knowledge we gain from the cooperation is indispensable.

KRISTIAN EHRHORN  
KJÆRULF PEDERSEN A/S

This all makes the task sound much simpler than it actually is. Although theoretically possible, it remains to be seen whether sufficiently efficient catalysts can be developed, and we still have some distance to go before the idea can become a commercial product.

### Matching expectations and yield

Cooperation between industry and research communities can sometimes create friction. In this case, however, the cooperation between both parties was rewarding and worth the effort. Still, in seeking to cooperate, two parties have different rationales and criteria for success, explains Ehrhorn. In his experience, it helps if both parties are clear about what they want and expect to achieve. Still, he acknowledges that cooperation can be tremendously difficult and may take some time to achieve results.

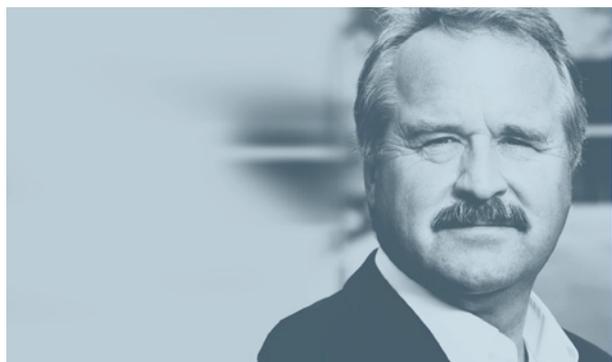
However, the knowledge we gain from this kind of cooperation is indispensable, he stresses.

CINF is keen to be challenged by tangible problems, but research cooperation must emphasize research.

"If we knew in advance that something was possible," Chorkendorff explains, "it would not be research but rather development, and that, I think, should be left to the companies. This is why research entails – and must always entail – a risk. We have clearly stated our desire to participate in exploring new and more efficient catalysts capable of producing the required results, but we cannot promise that it can be done."

In addition to Kjærulf Pedersen A/S, CINF also cooperates with other industrial businesses, always on the condition that a research question worth answering can be formulated. Luckily, many companies are adept at formulating such questions as part of their business. These companies gain real benefits from cooperating with the Center of Excellence, Chorkendorff explains.

"They incorporate the latest knowledge into their product development," he points out, "while we create new knowledge in general and, perhaps most important, train the engineers/researchers who may later work for these companies and contribute their profound insight into the underlying principles used in future product development."



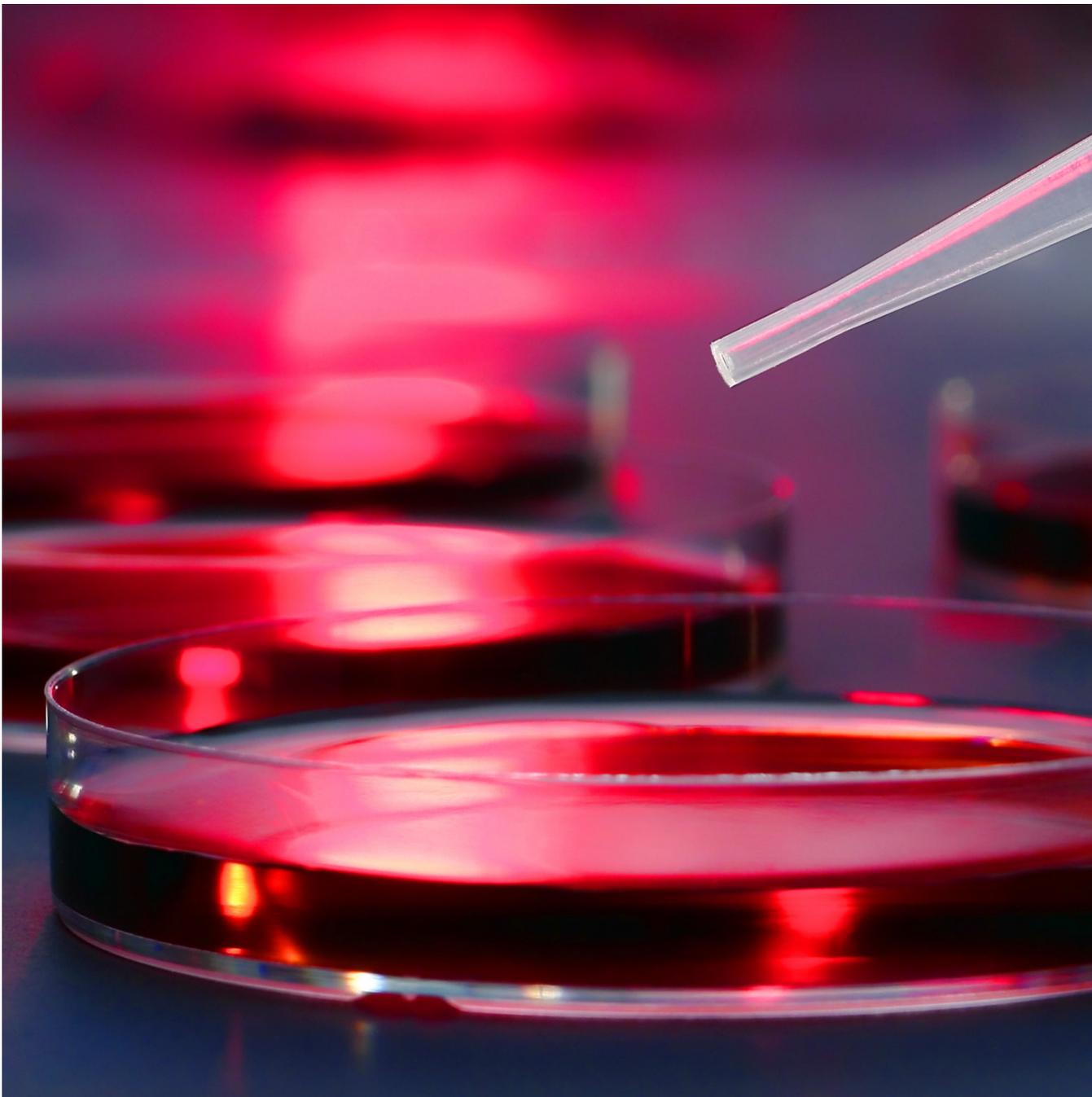
#### FACTS:

Center leader / Ib Chorkendorff  
Center for Individual Nanoparticle Functionality (CINF)  
Host institution / Technical University of Denmark  
DNRF grant / DKK 84 million  
Period / 2005-2015

[www.cinf.dtu.dk](http://www.cinf.dtu.dk)

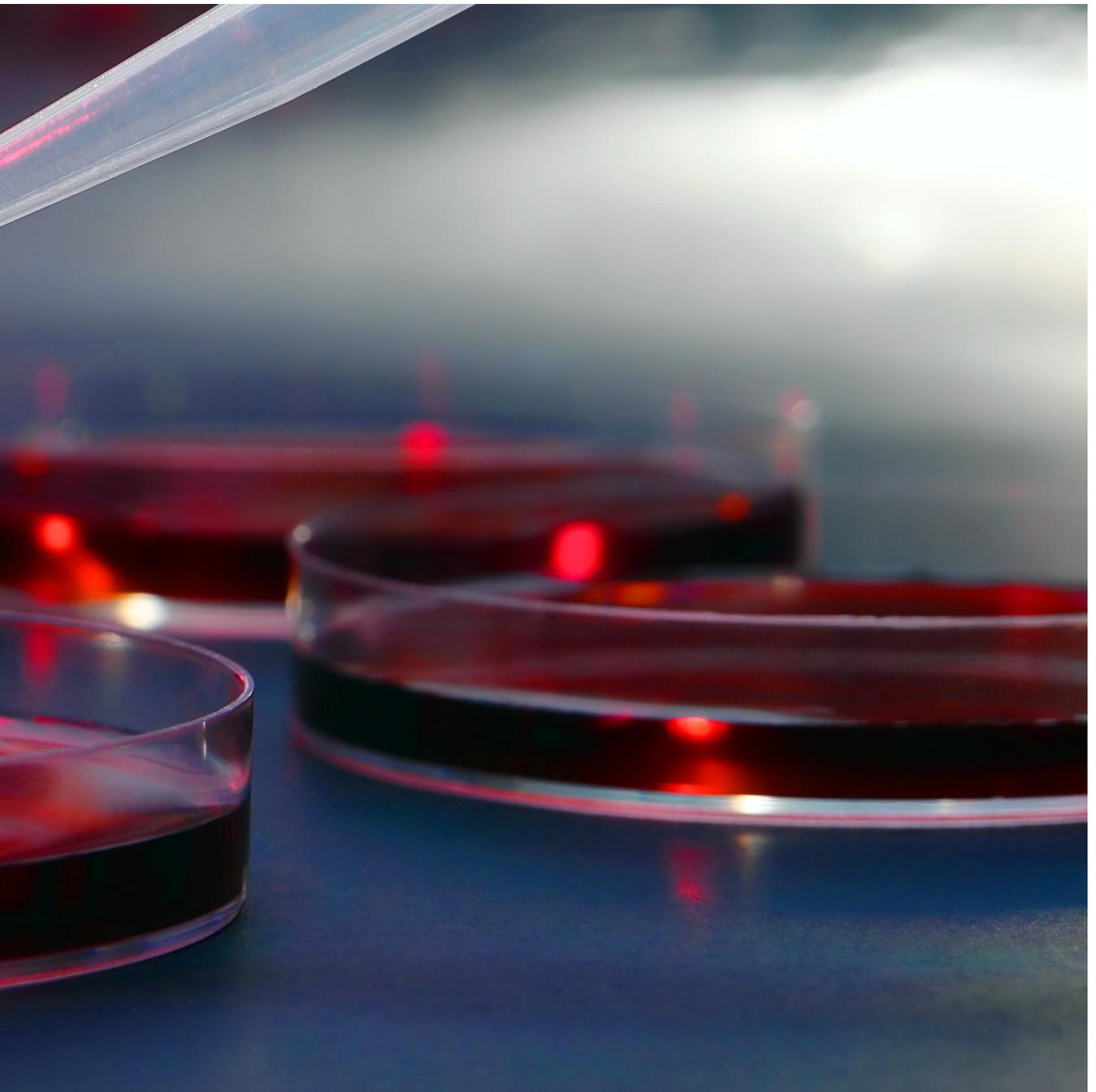
10

MOLECULES CAN  
PREVENT CANCER  
TUMORS FROM  
GROWING



Research is a lot more fun if it has applications in the real world.

KRISTIAN HELIN  
CENTER FOR EPIGENETICS



## MOLECULES CAN PREVENT CANCER TUMORS FROM GROWING

Cooperation between the Center for Epigenetics and the spin-out company, EpiTherapeutics, greatly inspires the young researchers working at the center. They can see that top research can, in fact, be combined with applications.

Researchers and companies around the world are striving to find efficient methods for curing cancer and reducing and preventing the unimpeded growth of cancer tumors. The Danish company EpiTherapeutics is no exception. However, the company is taking different avenues than most by exploiting epigenetic mechanisms. Instead of focusing on changes in the genetic material, our DNA, the company is trying to develop drugs in the form of tiny molecules capable of regulating the way in which the genetic DNA code is read. The hope is that this will lead to new ways of treating diseases like for instance prostate cancer.

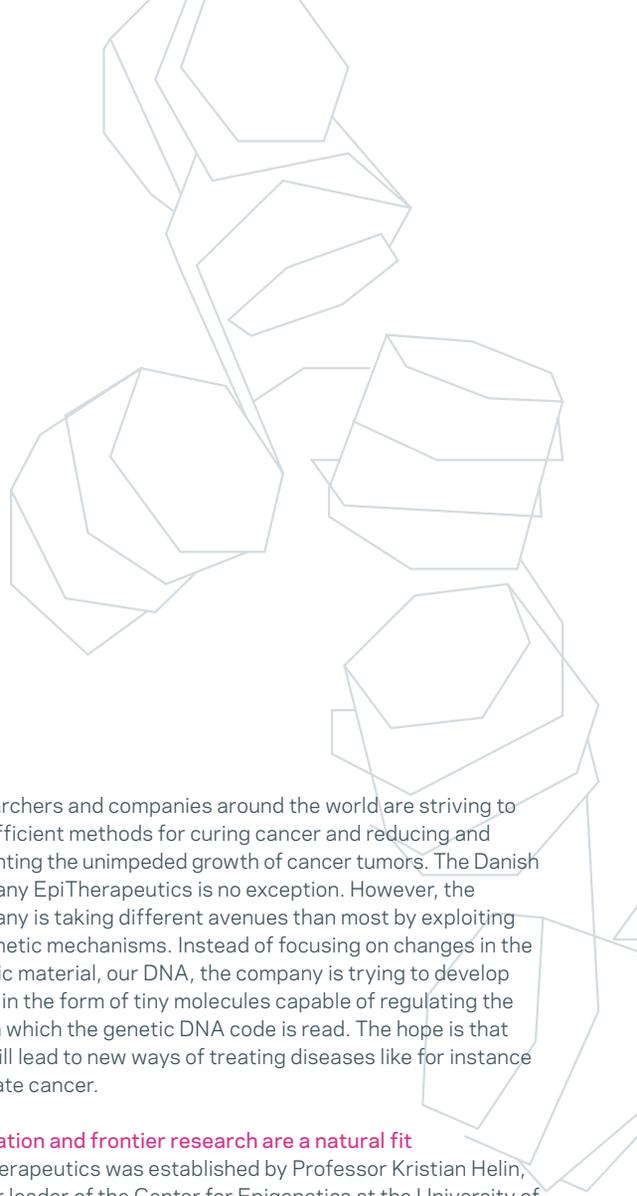
### **Innovation and frontier research are a natural fit**

EpiTherapeutics was established by Professor Kristian Helin, center leader of the Center for Epigenetics at the University of Copenhagen. Research results from this center provide the foundation on which the business is built. Researchers described how a specific group of enzymes could, so to speak, turn our genes on and off. The results, published in leading scientific journals, enabled Helin and four other staff members to establish EpiTherapeutics in 2008. However, frontier research remains Helin's top priority, and he thinks that the Center for Epigenetics is at the global vanguard in its field of research.

"The Center for Epigenetics engages in frontier research and should be measured against this research," emphasizes Helin. "However, research is a lot more fun if it has applications in the real world."

This viewpoint is so ingrained that he does not have to compel himself or his researchers to consider how research turns into innovation.

"It just happens," he points out. "But it is clear that our spin-out inspires young researchers at the center. They can see that top research can, in fact, be combined with applications."



EpiTherapeutics currently has 20 employees and is about halfway down the long road from idea to completed drug.

#### Long way from idea to prescription

EpiTherapeutics currently has 20 employees and is about halfway down the long road from idea to completed drug. So far, financial supporters have invested millions of Danish kroner in the spin-out, and the hope is to conduct clinical trials within a couple of years.

The money may be lost if the trials prove futile. On the other hand, if the trials go well, the owners will be able to choose between investing additional amounts in further development or selling patent rights or even the entire business.

As an original promoter, Helin is above all gratified that EpiTherapeutics has already proved to be an interesting partner for major biotech companies.

“But it would be fantastic to succeed in creating a new drug that increases the survival rate of cancer patients,” he says.

#### Frontier researchers are attractive partners for industry

According to Helin, the largest players in the biotech industry already regard EpiTherapeutic as an interesting partner, primarily because the company is founded on excellent research.

In his experience, major biotech businesses and the pharmaceutical industry are extremely interested in cooperating with leading research communities like the Center for Epigenetics on the applications of their results. This is because industry may lead the way for applied research, but academic researchers are the trailblazers of frontier research.

“So to be interesting partners, academic researchers need good opportunities to immerse themselves in free frontier research,” Helin explains. “At the same time, it is crucial that new businesses are located in the place where research occurs, as this facilitates the strong cooperation on driving new scientific findings toward commercialization.”



Photo: Martin Mydtskov

#### FACTS:

Center for Epigenetics  
Center leader / Kristian Helin  
Host institution / University of Copenhagen  
DNRF grant / DKK 111 million  
Period / 2007-2017

[www.epigenetics.ku.dk](http://www.epigenetics.ku.dk)

14

NEW TECHNOLOGY  
PREVENTS TOXINS  
FROM REACHING  
PLANT SEEDS



The results we achieve by conducting research into universal biological processes often prove directly beneficial to society, the environment or human health.

BARBARA HALKIER  
CENTER FOR DYNAMIC MOLECULAR INTERACTIONS (DYNAMO)



Photo: leodikan/123RF

# NEW TECHNOLOGY PREVENTS TOXINS FROM REACHING PLANT SEEDS

Curiosity-driven research has led to a discovery with vast practical applications. This discovery has struck a chord with many, catching the attention of not just researchers but also of companies with commercial interests.

"We never dared hope that it would come to this. This breakthrough is of a magnitude that will open unseen opportunities in plant breeding," explains Professor Barbara Halkier, who heads the Center for Dynamic Molecular Interactions (DynaMo) at the University of Copenhagen.

The research finding about which Halkier is so elated came after a long and arduous quest to understand some fundamental processes in plants. Curiosity was the engine driving this research, as well as a desire to gain new knowledge about biological processes at the molecular level. This quest culminated, however, in results that hold vast commercial potential and can also benefit the environment and human health.

## From model plant to universal principles

A good model system is required to identify fundamental biological processes. The DynaMo center uses *Arabidopsis* (thale cress). This plant is ideal because its genome is rather small and its life cycle is just eight weeks. Not only researchers at DynaMo but also system biologists worldwide use *Arabidopsis* as a model plant, meaning that a wealth of biomolecular research tools, mutant collections and databases have been developed specifically for this plant. However, Halkier and her group are the first to have succeeded in producing a plant with seeds without glucosinolates, the defense compounds the plant produces to defend it against insects and microorganisms.

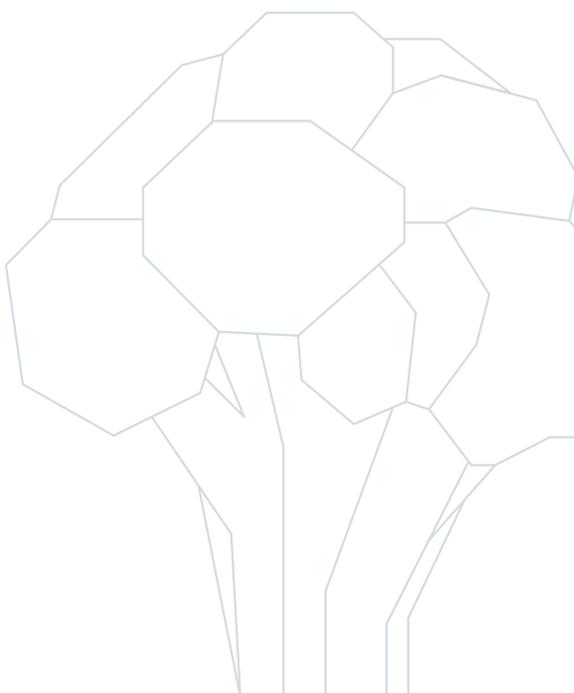
This discovery has numerous practical applications and has therefore struck a chord with many people, catching the attention not only of research communities but of farmers and companies with commercial interests. The reason behind this interest is that the discovery has created the basis for developing a technology that allows unwanted toxins to be removed from edible plant parts.

## Commercial possibilities and good news for the agricultural sector

*Arabidopsis* is a weed and not used as feed for domestic animals or humans. However, *Arabidopsis* is closely related to the oilseed rape, which also produces glucosinolates for defense. Unfortunately, the kind of glucosinolates found in rape is toxic to life forms besides insects and fungi. Many large animals, including pigs, can tolerate rape only in small amounts.

This is unfortunate because rape is a very common crop in Denmark, where it colors the landscape bright yellow during the early summer. In fact, rape is the third most common oil-producing crop in the world. Farmers are well aware that the protein-rich rape cakes that are left after the rapeseed oil has been pressed can be used for pig feed only to a limited extent. For this reason, Denmark imports massive amounts of soya cakes for its pigs.

A rapeseed plant without glucosinolate in its seeds (and thus in the rape cake), but that retains its natural defense compounds in the rest of the plant is almost too good to be true. Nevertheless, this is exactly what the new discovery of the DynaMo center has made possible. Bayer Crop Science, one of the world's lead plant biotechnology companies, has no doubts about the potential and has formed a collaboration with the center to transfer its new scientific advances to rape.



As a result, this research finding comes with an unexpected bonus for both farmers and the environment.

#### Cancer-preventive cabbage

Not only does the research at DynaMo have the potential to make life easier for pigs and farmers, it also contributes with research that may have an immediate impact on human health. Halkier explains:

“The results we achieve by conducting research into universal biological processes often prove directly beneficial to society, the environment or human health.”

Take, for instance, the well-known cabbage broccoli. One of the glucosinolates produced in large volumes by broccoli is glucoraphanin, a substance believed to have a cancer-preventive effect. Halkier’s group has succeeded in mapping all the steps required for broccoli to produce glucoraphanin.

The center’s knowledge about glucoraphanin has led to cooperation with the British Institute of Food Research with the aim to document that glucoraphanin is indeed, the substance giving the cancer-preventive effect.

“Simultaneously, we are focusing on finding a way to produce the substance for use in dietary supplements and drugs,” says Halkier. “The collaboration builds a bridge between frontier research and innovation, offering fertile ground for growth in the food and drug industries.”

#### Pest control without pesticides

Glucosinolates are highly efficient defense compounds but are available only in plants from the Brassicaceae family such as Arabidopsis, rape, cabbage and a wide array of other utility plants. After having identified the genes that lead to the production of glucosinolates in Arabidopsis, researchers have succeeded in transferring them to tobacco plants. This feat has paved the way for a Danish-South American cooperative effort to increase the resistance of the potato plant to disease.

“We have chosen to test the strategy in tobacco, which like the potato belongs to the nightshade family, because tobacco is easier and faster to work with,” explains Halkier.

The tests were successful, and with partners at the International Potato Center in Peru, center researchers are working to introduce the genes into the potato plant. This project holds enormous potential because potato farmers worldwide will no longer have to use the vast amounts of pesticides used today. Pesticide consumption for potato farming is disproportionately high. In Denmark, potatoes are grown on 6% of the agricultural land, but as much as 25% of total pesticides are used on the potato fields. As a result, this research finding comes with an unexpected bonus for both farmers and the environment.



Photo: Susanne Østergård

#### FACTS:

Center for Dynamic Molecular Interactions (DynaMo)  
Center leader / Barbara Halkier  
Host institution / University of Copenhagen  
DNRF grant / DKK 49 million  
Period / 2012-2017

[www.dynamo.ku.dk](http://www.dynamo.ku.dk)

# 18

## COMBATING THE CONSEQUENCES OF CLIMATE CHANGE



Our competitive advantage is that we have based our business on original and groundbreaking basic research. We are more than "just" good at what we do. We have made research breakthroughs and translated our knowledge into practice.

LARS ARGE  
CENTER FOR MASSIVE DATA ALGORITHMICS (MADALGO)



Photo: Morten Mejlhede Rolsted

## COMBATING THE CONSEQUENCES OF CLIMATE CHANGE

It was not in the cards that a Center of Excellence in computer science would contribute solutions that would make climate change easier to manage. Nonetheless, this story aptly illustrates how solutions and crucial input can come from an unexpected source.

Flooded basements and sewers, temporarily closed roads and railways, and astronomical insurance and restoration bills, are some of the consequences of the extreme weather caused by climate change. Climate change is causing water to pour from more than the skies; flooding from the ocean is threatening coastal areas as ocean water rises in sync with global warming. The weather is difficult to change, but if the flood-prone areas are known in advance, we can take precautions that will save individuals and society a lot of trouble and expense.

### Flash Flood Mapping: A commercial success

It is tools that can supply precisely this knowledge that the software company Scalable Algorithmics (SCALGO) have developed. SCALGO is a spin-out from the Center for Massive Data Algorithmics (MADALGO) at Aarhus University. The center is managed by Professor Lars Arge, who is also a founder of SCALGO.

"It gives me enormous personal satisfaction to see our research used in practice and that it makes a difference to people," he says.

And that difference is quite tangible. SCALGO has not only developed unique software sold to both private companies and public institutions, but it has also calculated the consequences of rising sea levels on behalf of the Danish Ministry of the Environment. Furthermore, in cooperation with COWI, SCALGO has developed the Flash Flood Mapping tool (Skybrudskort@ in Danish), which shows the areas where flooding can be expected during extreme rain. This is useful knowledge for someone considering buying a house or installing new roof gutters or drainage systems, but it is also a tool that local authorities and regions can use to benefit their climate change planning. With extreme weather as a factor to be reckoned with, local Danish municipalities and regions clearly need to know where rainwater will go and where to initiate response measures. This knowledge is vital when they plan new urban areas, prioritize sewer renovation, assess house prices, divert road water, and much more.

As a result, the Flash Flood Map has already been sold to more than ten local authorities and the entire Central Denmark Region, and the map is being developed to cover all of Denmark.



What drives me as a scientist is the desire to understand and know more. But when you gain new insight, I think that you have an obligation to reflect upon whether and how this insight can be used in practice and then bring your knowledge into play.

#### Combating climate change

The Flash Flood Mapping tool can make it easier to tackle some of the challenges posed by climate change. However, MADALGO research is neither on climate change nor hydrology. Most of the center's researchers are computer scientists, and the center is among the world's best at processing large amounts of data. This ability and knowledge has many potential applications, and the spin-out SCALGO was established to develop and exploit the commercial aspect of the center's research.

"We have not done any research into climate change or flooding but we know something about handling massive amounts of data, which is previously what is needed in the realization of a realistic flash flood mapping tool," explains Arge.

In theory, the consequences of a given amount of rainfall are actually not that difficult to estimate. Water always runs downhill, and if the terrain conditions are known it should be relatively simple to calculate where the water will accumulate and where the risk of flooding is greatest. The terrain conditions in Denmark are well known and well described. For example, COWI has surveyed the entire country and produced a terrain model with a 2x2-meter resolution. The model divides Denmark into 26 billion cells with a height each that can be used to calculate where the water will run during extreme rain. This detailed terrain model is necessary to be able to calculate precisely where rainwater runs, but the plethora of data was also what made the task impossible to solve until SCALGO came along.

#### Research foundation offers a competitive edge

It was not in the cards that a Center of Excellence in computer science would contribute solutions that would make climate change easier to manage. Nonetheless, this story aptly illustrates how solutions and crucial input can come from an unexpected source.

"What drives me as a scientist is the desire to understand and know more," Arge points out. "But when you gain new insight, I think that you have an obligation to reflect upon whether and how this insight can be used in practice and then bring your knowledge into play. You must keep your eyes open to practical problems and try to develop the skills required to solve these problems." Arge sees a natural interplay between basic research and practical applications. In fact, this neatly summarizes his view of research in general.

"Our competitive advantage is that we have based our business on original and groundbreaking basic research. We are more than 'just' good at what we do. We have made research breakthroughs and translated our knowledge into practice," he continues.

"It is extremely satisfying to see our knowledge translated into something practical," Arge concludes. "In many branches of science, it takes a long time before you are sure that the basic research breakthroughs you have achieved will also bring about change. Here the road from realization to market is much shorter."



#### FACTS:

Center for Massive Data Algorithmics (MADALGO)  
Center leader / Lars Arge  
Host institution / Aarhus University  
DNRF grant / DKK 73 million  
Period / 2012-2017

[www.madalgo.au.dk](http://www.madalgo.au.dk)

22

ONE WATER SAMPLE IS ALL  
IT TAKES TO DETERMINE  
THE BIODIVERSITY IN  
A LAKE OR AN OCEAN



It is extremely satisfying to see how  
our research can have a direct, positive  
impact on society.

ESKE WILLERSLEV  
CENTER FOR GEOGENETICS



# ONE WATER SAMPLE IS ALL IT TAKES TO DETERMINE THE BIODIVERSITY IN A LAKE OR AN OCEAN

Studies of genetic material (DNA) thousands of years old have shed new and surprising light on how animals migrated to Australia and America thousands of years ago and why Ice Age animals such as the mammoths and the woolly rhinoceros met such sorry fates. These kinds of studies are notoriously difficult to conduct. However, center leader, Professor Eske Willerslev, has repeatedly impressed international research communities and made the covers of the most prestigious scientific journals.

## From past to present

The methods developed by researchers at the Center for GeoGenetics for studying old DNA are now proving viable for today's problems. It is likely that that these methods will change the way animal life is monitored in lakes, in rivers and on land in the future. For instance, it will be easier to determine the stock of endangered fish and define meaningful fishing quotas.

"This is a quantum leap," says Willerslev.

The breakthrough came in 2011, when center researchers showed that animal life in lakes and streams could be analyzed on the basis of very small water samples. The water sample could not only identify the fish, insects, amphibians, crustaceans and mammals present in the lake, it could also show with surprisingly high accuracy the stock of the given animals in the lake. The group also showed that plant and mammal composition on land can be described by studying the DNA composition of very small soil samples.

## Commercial possibilities

Supported by the Danish National Advanced Technology Foundation, the Center for GeoGenetics has started working with Amphi Consult and Eurofins Miljø to develop a commercial kit for DNA detection in water. Amphi Consult already offers such solutions. In a brochure about the method, the company explains: "We haven't done away with rubber boots, nets, head-lights and special microphones, but DNA technology is an excellent new tool."

"It is in large part thanks to my Ph.D. student Philip Francis Thomsen and student Jos Kielgast that the DNA measurements of water have gained so much commercial interest and popularity," Willerslev says.

"They immediately saw the huge financial potential of the discovery," he adds, "and their keen interest in natural conservation and biodiversity gave them the right network to generate the commercial interest. Without them, we would not have come into contact with Amphi Consult, and the project would not have been commercialized and disseminated to the extent that it has."

The results produced by the method are so good that Willerslev himself was quite surprised at its efficiency.

"Even soil samples can tell us a lot about the plants and animals living in a certain area," he explains. "We have already tested the method in an animal park where we already know the variety and number of animals found in the area."

Instead of spending time and energy on manually counting animal life, biologists and environmental authorities in the future can find the number in almost no time.

## From curiosity-driven frontier research to unforeseen applications

"It has taken many years to gain the realization and knowledge we now enjoy," Willerslev points out. "Fundamentally, we begin with studies of old DNA in soil that my partner, Anders J. Hansen, and I conducted in 2003. Now, I think the technology is close to being applied on a large scale. I expect compilation methods to have changed radically within five years."

If anyone does, Willerslev represents the type of researcher driven to give society new knowledge and insight into areas others scarcely thought possible. However, he says that the past several years have made him keenly aware of how research can also be used in other contexts.

Research into the past will have unforeseen implications for the animals, humans and environment of today.



"It is extremely satisfying to see how our research can have a direct, positive impact on society," he says.

He explains that the technique for finding faint DNA traces also opens brand-new vistas in medicine. To start with, certain types of cancer or inflammations may be caused by as-yet undiscovered viruses. Finding unknown viruses mixed with human material is as difficult as studying old DNA. Willerslev thinks that this may be one reason why traditional methods have been unable to find such viruses.

"In both cases, you hold a tiny bit of interesting DNA in a sea of contamination," he adds. "It is like looking for a needle in a haystack."

"Following the work of mapping the first genome from a pre-historic human, which gained international attention, I was contacted by Lars Peter Nielsen from Statens Serum Institute, who thought that our methods might be used to find new viruses," Willerslev points out. "Together we developed what would become the Cancer Pathogen Project supported by the Danish National Advanced Technology Foundation.

"We master the techniques for making such analyses, but whether we can eventually find new viruses that cause cancer is obviously extremely uncertain," Willerslev concludes. "These studies are very risky, but a discovery could have far-reaching implications."

Willerslev considers it both a key task and an exciting challenge to make research breakthroughs in one field and apply them in others. He thinks that researchers can easily see the possibilities. On the other hand, they need assistance in many areas.

"Researchers need to know where to take their ideas," he maintains. "For instance, I know nothing about making investments and establishing companies."



#### FACTS:

Center for Geogenetics  
Center leader / Eske Willerslev  
Host institution / University of Copenhagen  
DNRF grant / DKK 50 million  
Period / 2009-2014

 [www.geogenetics.ku.dk](http://www.geogenetics.ku.dk)

26

RESEARCH

A MATTER  
OF LIFE  
OR DEATH



The lives of 6500 children could be saved every day if our results and recommendations were used globally.

CHRISTINE STABELL BENN  
RESEARCH CENTER FOR VITAMINS AND VACCINES (CVIVA)



Photo: Bandim Health Project

A MATTER  
OF LIFE  
OR DEATH

Research at the Center for Vitamins and Vaccines (CVIVA) provides fundamental new insights into the immune system and contributes new knowledge that may save lives and improve the health of people all over the world.

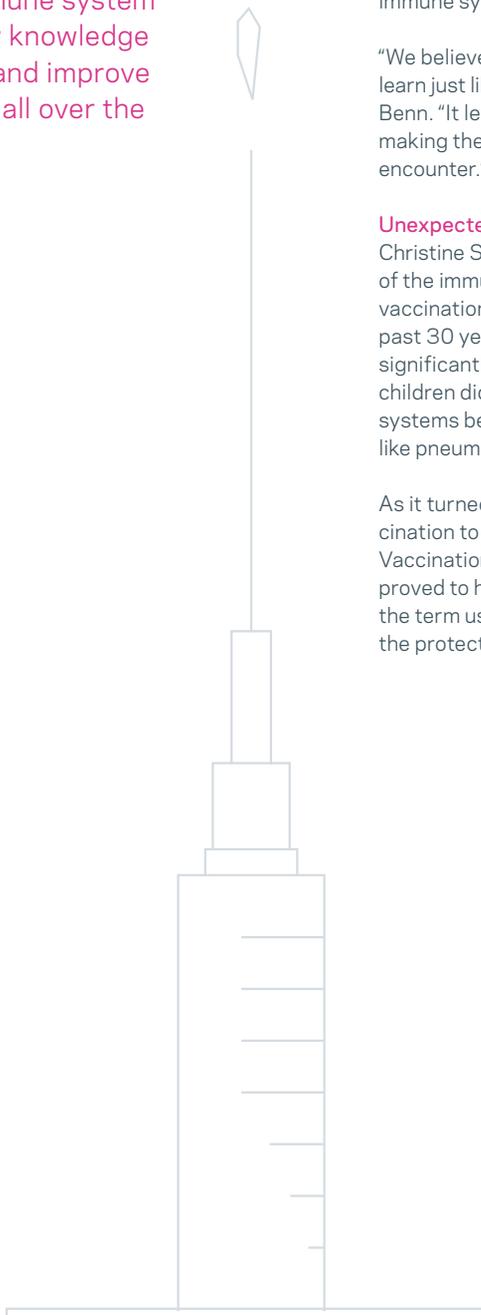
CVIVA supports what can best be described as a paradigm shift. For many years, researchers at the center have argued that not only do vaccines provide protection against specific diseases, but they also have a more general effect on the immune system.

“We believe that the immune system is a smart system that can learn just like the brain,” explains center leader Christine Stabell Benn. “It learns from its experience with specific diseases, thus making the body more capable of fighting diseases it has yet to encounter.”

**Unexpected spin-off**

Christine Stabell Benn and her colleagues base their conception of the immune system as a learning system on studies of vaccination programs carried out in Guinea-Bissau over the past 30 years. They saw how measles vaccines helped significantly reduce child mortality – not only because the children did not get measles but also because their immune systems became stronger and better able to fight diseases like pneumonia and malaria.

As it turned out, the measles vaccine was not the only vaccination to have a positive impact against unrelated diseases. Vaccinations against smallpox, tuberculosis and polio also proved to have positive side benefits – or non-specific effects, the term used to describe the added effect of a vaccine beyond the protection it provides against a specific disease.



### Age and gender matter

CVIVA researchers have also discovered that the overall effect of vaccines depends on how early in life one receives the vaccines and the order in which they are received. Furthermore, the researchers have discovered fundamental differences between the immune systems of boys and girls. This suggests that the effects of some vaccines are highly gender determined.

The vast majority of vaccines have positive, non-specific effects. This is especially true of "live" vaccines, in which people are inoculated with a weak form of the disease the immune system is intended to fight, such as vaccines against measles and tuberculosis. However, some vaccines may have negative effects, especially for girls. This occurs, for example, in connection with inactivated vaccines or "dead" vaccines, such as those used against tetanus, diphtheria and pertussis. In girls, the vaccine seems to make them more susceptible to other infections.

Benn stresses that this obviously does not mean that anyone should forgo vaccination in specific situations when it is required. At the same time, however, vaccination programs can clearly be designed much more intelligently if we know more about both the non-specific effects and the basic processes of the immune system.

### CVIVA researchers have discovered fundamental differences between the immune systems of boys and girls.

### Saves lives and improves health

CVIVA's research clearly has an enormous social relevance. Low-income countries with high child-mortality rates, in particular, have much to gain from introducing vaccination programs based on CVIVA's recommendations.

"The lives of 6500 children could be saved every day if our results and recommendations were used globally," says Benn, referring to an assessment made by other researchers. "However, countries other than those with low incomes could similarly see health improve. Denmark and other high-income countries could also benefit."

Studies indicate that the vaccine against tuberculosis (known as the Calmette vaccine), part of the Danish vaccination program until about 30 years ago, has also had a more general and positive effect on health, perhaps helping to reduce the number of allergy sufferers. CVIVA researchers are in charge of a new, major Danish experiment aiming to show how the Calmette vaccine affects general health.

"I am very excited to see the outcome of this experiment, and I expect that it will provide fundamentally new insight into the immune system," says Benn.



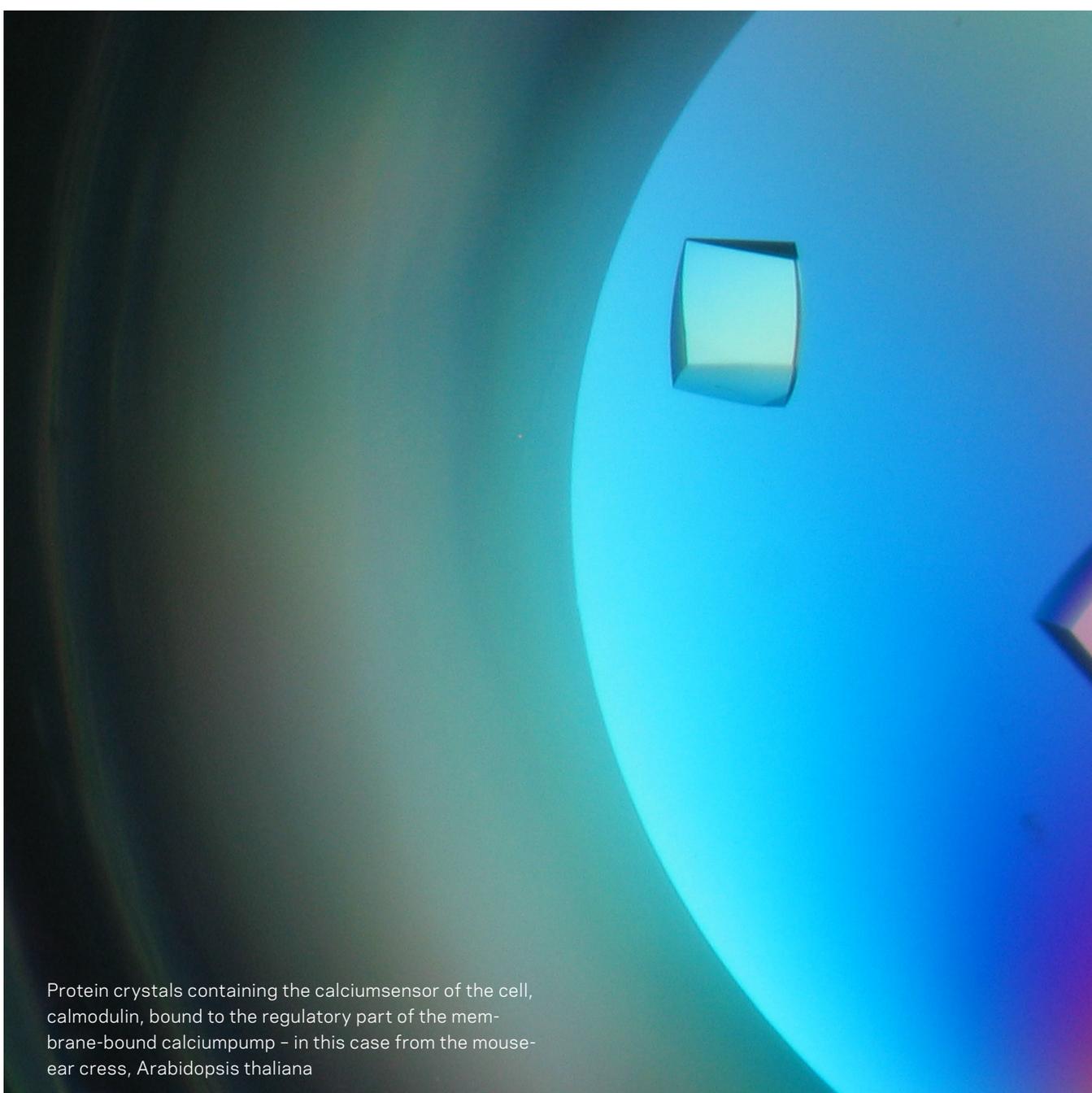
#### FACTS:

Research Center for Vitamins and Vaccines (CVIVA)  
Center leader / Christine Stabell Benn  
Host institution / Statens Serum Institut  
DNRF grant / DKK 58 million  
Period / 2012-2018

 [www.cviva.dk](http://www.cviva.dk)

# 30

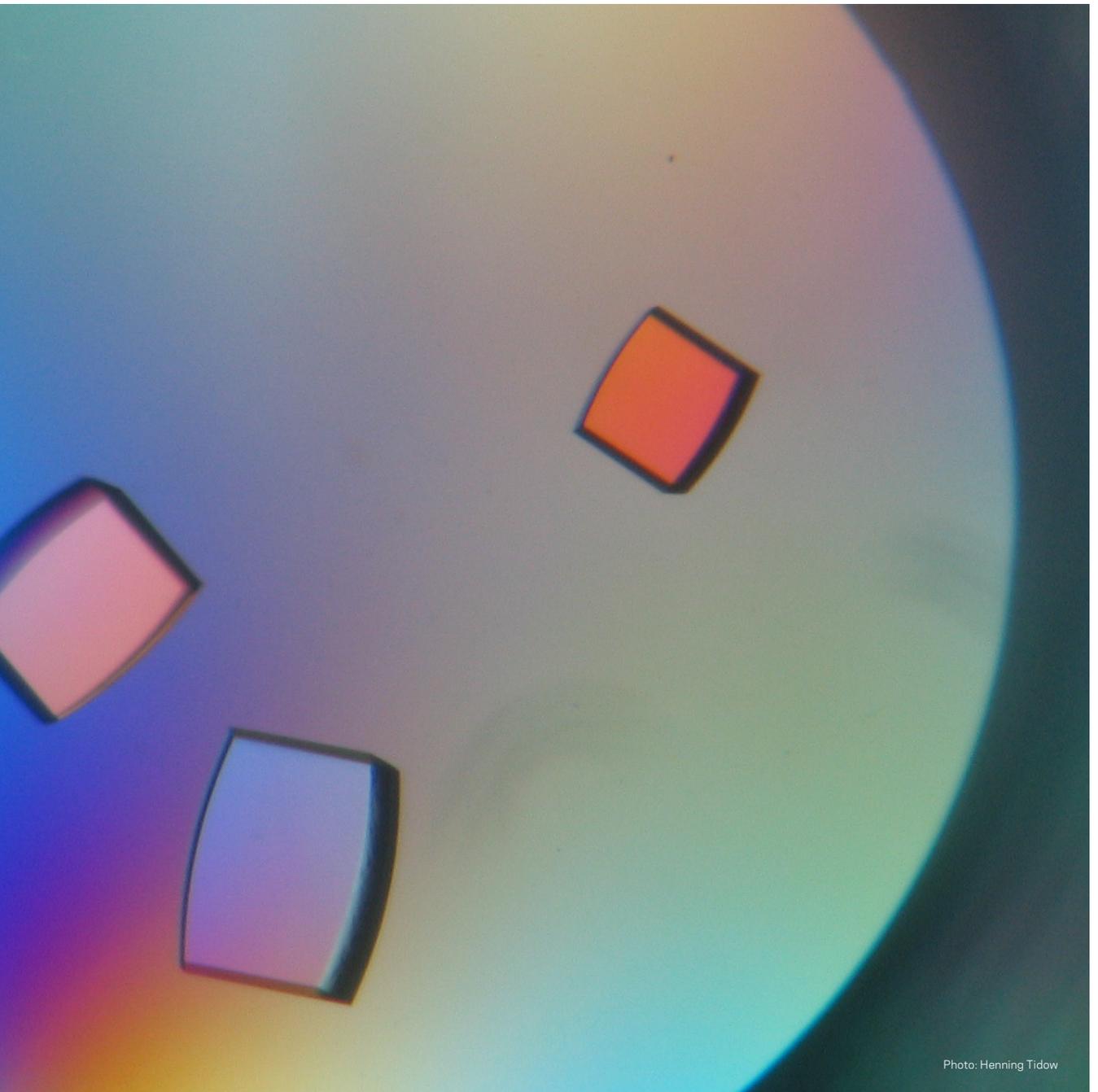
## FRONTIER RESEARCH GIVES NEW COMPANIES A UNIQUE ADVANTAGE



Protein crystals containing the calcium sensor of the cell, calmodulin, bound to the regulatory part of the membrane-bound calcium pump - in this case from the mouse-ear cress, *Arabidopsis thaliana*

In a knowledge-based economy, being the first to produce new, original knowledge is a clear competitive advantage.

POUL NISSEN  
CENTRE FOR MEMBRANE PUMPS IN CELLS AND DISEASE (PUMPKIN)



## FRONTIER RESEARCH GIVES NEW COMPANIES A UNIQUE ADVANTAGE

The PUMPkin research center cooperates closely with the spin-out company Pcovery, to the great benefit of both.

"We have been brought into the world to engage in research, but we must also help establish new businesses and educate new generations," asserts Poul Nissen, leader of the Centre for Membrane Pumps in Cells and Disease at Aarhus University. "The university is duty-bound to contribute to renewing society in every possible way – also by establishing new businesses." This is the tone that Nissen sets for the center's activities.

### **Creates innovation and saves lives**

Pcovery ApS is just such a company to emerge from the Center of Excellence, focusing on developing medicine against potentially lethal fungal diseases. These include pneumonia and blood poisoning caused by fungi, disease that are striking and killing a growing number of people, not least the elderly and people with weakened immune systems.

Many pathogenic fungi have developed resistance to existing drugs, which are usually also narrow spectrum and therefore often cure one infection only to pave the way for another.

Pcovery ApS wants to develop broader-spectrum drugs that attack the fungal cells by targeting a protein found in the cell membranes of all fungi. This is an unprecedented opportunity made possible because the Center of Excellence has mapped the three-dimensional structure of various proteins of this type. Specifically, Pcovery ApS is attempting to find small molecules that can bind to the protein and block its function, thus attacking the fungal cell at a place vital to its survival.

### **World-class interaction**

Developments at Pcovery ApS are based on research into the role ion pumps play in controlling the transport of substances into and out of the cells through the cell membrane. This has been successfully studied in Aarhus and Copenhagen for more than half a century. In 1957, Jens Christian Skou discovered the sodium-potassium pump, a discovery for which he received the Nobel Prize in Chemistry forty years later. The Centre for Membrane Pumps in Cells and Disease, also known as PUMPkin, is thus carrying on a proud research tradition.

However, Pcovery ApS does more than put knowledge from the center into practice.

## Spin-out initiatives are fantastic learning environments for aspiring entrepreneurs

"Pcovery ApS has discovered new, unique substances that can form the basis of new drugs. These discoveries are also meaningful to frontier research, as they give us new information about how the pumps work," says Nissen

As an example of how the two entities interact, Nature has published a joint article by Pcovery ApS and PUMPkin on calcium pump regulation. Thus, knowledge sharing between research and industry can be reciprocal.

### Researchers are the first to see the potential

Ion pumps in the cell membrane consist of large, complex protein molecules, and it is the structure and understanding of these molecules that is the focus of PUMPkin's research. This means that researchers gain the first insight into how to turn the "molecular dials" and what potential this holds for innovation and development.

"In a knowledge-based economy, being the first to produce new, original knowledge is a competitive advantage," Nissen says, "and this is where the Center of Excellence has something special to offer.

"At the same time," he points out, "it is incredibly satisfying and motivating to see the fruit of your labor being taken to the next level and applied in a way that can hopefully help save lives and benefit society in general."

### Aspiring entrepreneurs and young blood

Without doubt, research results count the most for Nissen, and he is driven by his curiosity to understand complex relationships. He emphasizes, however, that even though one might work with frontier research, establishing new businesses and joining forces with industry are important – and in his case completely natural.

"Profit should not be the driver of cooperation," Nissen insists. "We need to do what it takes to develop our researchers and industry. Spin-out initiatives are fantastic learning environments for aspiring entrepreneurs, even though many projects will never culminate in successful drugs and companies. In addition to Pcovery ApS, we also have two projects in the development phase that could become new businesses, and yet another is in the pipeline."

He also has an opinion about how to get a new business off to the best start.

"The 'old professor' should not be the driving force in a start-up. Rather, young researchers should take on the task, while the old professor must nurture the desire to establish one's own business and ensure that the frontier research environment is always able to offer unique opportunities," Nissen says.

"I willingly support young researchers who strike out to start a business, and personally, I aim at having a small share in many projects rather than playing for high stakes on a single project," he concludes.



Photo: Lars Kruse/AU Foto

### FACTS:

CENTRE FOR MEMBRANE PUMPS IN CELLS AND DISEASE (PUMPkin)  
Center leader / Poul Nissen  
Host institution / Aarhus University  
DNRF grant / DKK 106 million  
Period / 2007-2017

 [www.pumpkin.au.dk](http://www.pumpkin.au.dk)

34

TEXTILES

OF THE PAST  
INSPIRE TODAY'S  
DESIGNERS



It is important for us to share our results and make research available to interested parties.

MARIE-LOUISE NOSCH  
CENTER FOR TEXTILE RESEARCH (CTR)



OF THE PAST  
INSPIRE TODAY'S  
DESIGNERS

New knowledge about the textiles, environment and society of the past benefits today's and tomorrow's designers.

When museum visitors today see that ancient garments had bright colors, they can give a little salute to the Center for Textile Research. The center has conducted comprehensive technical and historical analyses to attain new knowledge about clothing of the past and thus established that those faded finds contain traces of vivid colors. Although the main purpose of the Center for Textile Research is to study the historical relationship between textiles, environment and society, the new knowledge also benefits designers of today and tomorrow.

**Ancient design in new clothes**

Textile researchers attend workshops organized for companies by the Center for Culture and Experience Economy, an independent public institution founded by the Ministry of Culture and the Ministry of Business and Growth, whose goal is to generate growth and innovation through experience-based business development. The researchers have also held courses for students at the Kolding School of Design.

"We recognize that designers' tasks differ from ours, but both we and the designers benefit greatly from our dialog. It is important for us to share our results and make research available to interested parties," emphasizes Marie-Louise Nosch, leader of the Center for Textile Research.

Thus, the center's research may underlie future fashion design inspired by the clothes worn by ancient warriors and Renaissance nobles. Nosch gives another example illustrating the significance of research outside the narrow group of researchers:

"Occasionally, directors of historical films and plays ask us for advice," she says.

We recognize that designers' tasks differ from ours, but both we and the designers benefit greatly from our dialog.

#### Danish textile research with international impact

In recent years, the Center for Textile Research has made Denmark an international textile research hub. This is primarily due to the abundance of textiles in Danish museum collections compared with those in other countries.

"This can be explained by the ancient burial traditions and, not least, the soil in Denmark, which have both served to preserve many materials in bogs," says Nosch.

Since its establishment in 2005, the Center for Textile Research has been able to set the agenda for textile research in Europe. Thanks to two major lecture and study tours to China and India in 2009 and 2012, the center has also established a global reputation.

#### Clothing remnants testify to power and social structure

Researchers study ancient textiles as a means of explaining migration, trade routes and linguistic contexts. This is part of the research development seen in recent years, in which textiles and clothing are not merely considered as objects in themselves but as holding answers to researchers' questions about production, the use of clothing and its role in a broader perspective.

In the same way as gold, textiles have been a means of showing wealth; studies of linguistic terms, weaving methods and wool types reveal a great deal about ancient communities. However, Nosch points out that an objective truth about how people

dressed in the past may be very hard to find, but researchers are now in a much better position to explain how they believe people dressed in the past and on what facts they base this view.

Research suggests that as early as the Bronze Age, about 3500 years ago, organized textile production took place in the Mediterranean area. People who were able to control, influence and organize textile production also had the power to influence and change society. Furthermore, research provides a more thorough understanding of an old craft and its practitioners and thus more in-depth knowledge about ancient communities.

Textile research is a research area involving conservators, restorers, archaeologists, historians and ethnologists and in which tools used in natural sciences are gaining increasing importance. The center's organizational affiliations help make the research useful to others.

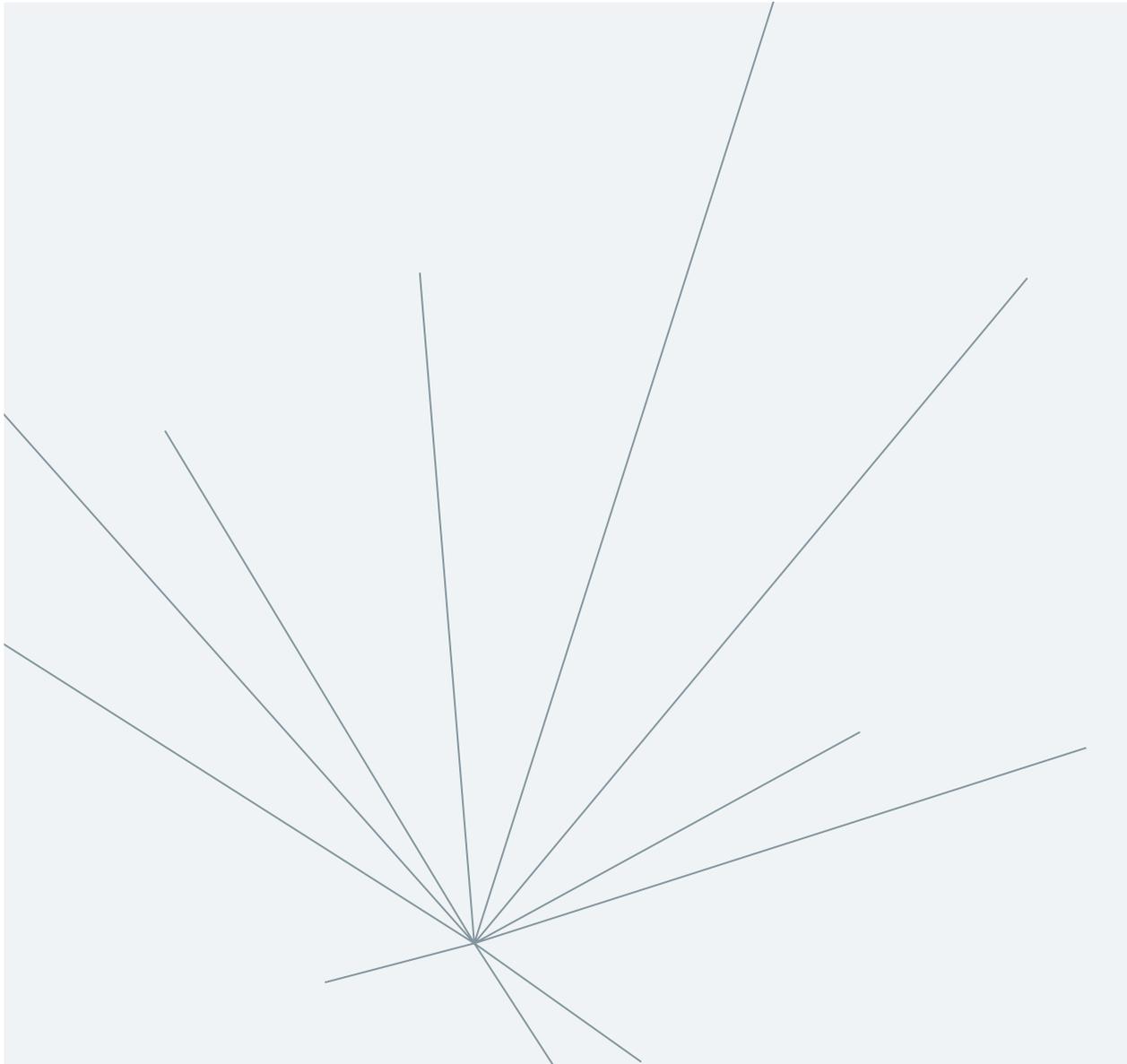
"We benefit from being part of the University of Copenhagen and the National Museum of Denmark and thus from our close relations with the many local museums around the country," Nosch explains. "This enables us to communicate our new discoveries quickly."



#### FACTS:

Center for Textile Research (CTR)  
Center leader / Marie-Louise Nosch  
Host institution / University of Copenhagen  
DNRF grant / DKK 45 million  
Period / 2004-2014

[www.ctr.hum.ku.dk](http://www.ctr.hum.ku.dk)



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# EXCELLENCE TRUST TRANSPARENCY

**The Danish National Research Foundation has three overall core values:**

**Excellence** is a concept that should pervade all aspects of the organization.

**Trust** stimulates creative research. Accordingly, the DNRF's philosophy is that center leaders should have considerable freedom in administrating the substantial and flexible grants at their disposal.

**Transparency**, fairness and quality are key words in the assessment process. Research communities must be able to trust the integrity of the Board of Trustees and the assessment and selection processes used by the foundation.

Great visions and new breakthroughs advance science and change the world, thus creating the basis for future discoveries and technologies.

Danish National Research Foundation  
Holbergsgade 14, 1  
DK-1057 Copenhagen K

T +45 3318 1950  
F +45 3315 0626  
E [dg@dg.dk](mailto:dg@dg.dk)

[www.dg.dk](http://www.dg.dk)