Danmarks
Grundforskningsfond
Danish National
Research Foundation

# THE DANISH NATIONAL RESEARCH FOUNDATION
## 12 NEW CENTERS OF EXCELLENCE

# ALWAYS STRIVING FOR EXCELLENCE

The Danish National Research Foundation (DNRF) is an independent organization established by the Danish Parliament in 1991 with the objective to promote and stimulate basic research at the highest international level at the frontiers of all scientific fields. The Center of Excellence (CoE) program is the main funding mechanism, but also a number programs and initiatives have been launched specifically targeted at increasing the level of internationalization of Danish research communities.

There is no fixed formula for creating a Center of Excellence, but they can all be described as ambitious, highly creative, of a high international caliber, original, scientifically daring, and with potential for groundbreaking results.

Centers of Excellence set the standard for how exceptional research should be conducted. By serving as hubs for excellent research, the centers are also expected to provide optimal environments for training the next generation of first-rate scientists. Research training and links to education are important ingredients in setting up Centers of Excellence. The foundations investments are expected to reach far into the future by fostering new top-researchers as well as new ideas.

The foundation is looking forward to completing the contract negotiations with the centers which will enable them to embark on their research endeavors in 2015.

"The establishment of the 12 new centers of Excellence is exhilarating to the foundation because a new center always holds a promise of original and innovative approaches and answers to research questions that will be of importance to society as a whole."

"The philosophy is that when excellent people work with problems they are most passionate about, groundbreaking results will follow."

**100 high-performing Center of Excellence – giving Denmark the important advantage**
With the addition of the 12 new centers that the foundation is prepared to fund, the number of Centers of Excellence funded by the DNRF will total 100. The CoEs have a major impact in the research community at large nationally as well as internationally.

In 2013 an international panel evaluated the Centers of Excellence program. Summarized in one sentence the panel concluded that the high-trust modes of operation of the DNRF and its CoEs have proven to be extremely successful. The panel was deeply impressed with the performance of the CoEs and stated that the orientation towards scientific excellence which characterizes the Danish research sector could not have been achieved to this extend without the DNRF and its CoE scheme.

The DNRF sees this tremendously positive evaluation as a great tribute to the research carried out at our centers and to the foundation it is an incentive to aspire even higher. We will continually consider how to adjust our funding mechanisms in order to be able to create the best possible framework for excellent research. We will stay open to new and risky ideas because we know it is a wise investment strategy to fund the dream projects of outstanding researchers whose performance and leadership qualities promise for groundbreaking results.

Prof. Liselotte Højgaard, Chair
and Prof. Thomas Sinkjær, Director

## THE FOUNDATION IN BRIEF

- The DNRF was established in 1991 as an independent organization with the objective of funding basic research at a high international level.
- In 1991, the foundation received an endowment of 2 billion DKK (267 M euro) from Parliament.
- The foundation's lifespan was extended in 2008 by a capital injection of 3 billion DKK (400 M euro) and another 3 billion is allocated on the next finance bill. This capital injection will ensures the existence of the foundation until 2036.
- Since 1991, the DNRF has committed itself to supporting Danish research institutions with 7,3 billion DKK (almost 1 billion euro).
- The DNRF spends approximately 450 M DKK (around 60 M euro) annually.
- The Center of Excellence program is the flagship of the foundation. A total of 100 centers have been established since 1993.

Entering into a contract for a Center of Excellence depends on agreement between the foundation and the management of the host institution regarding the terms of co-financing and future prioritizing of the research area.

# CENTER FOR HYPERPOLARIZATION IN MAGNETIC RESONANCE

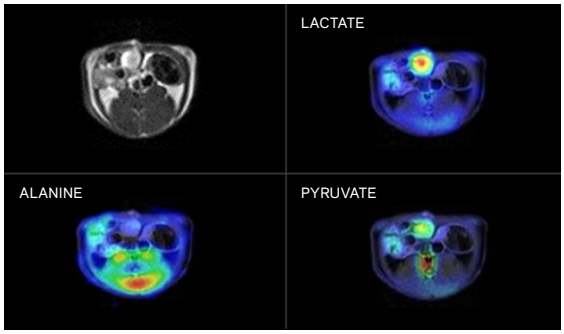
**Leader**
Principal Scientist,
Adj. Professor
Jan Henrik Ardenkjær-Larsen

**Location**
Technical University of Denmark

**Period**
2015-2021

**Grant**
55 mil. DKK

There is a tremendous potential to improve the sensitivity of Magnetic Resonance (MR) by hyperpolarization with broad scientific and commercial applications. Hyperpolarized MR is able to provide quantitative and specific information about chemical and biological processes on a sub-second timescale in a complex molecular background in vivo and in vitro. Hyperpolarization is achieved by Dynamic Nuclear Polarization (DNP), and allows us to enhance the MR signal by more than 10,000-fold and thereby enable experiments that would otherwise be impractical or even impossible. One of the most compelling applications is in medical imaging, where it opens a window into cellular metabolism and provides a tool to monitor disease progression and response to treatment. Hyperpolarization by DNP raises many fundamental questions, and a better theoretical description is needed. The aim of the Center of Excellence is to address these questions.




*Conventional cross-sectional MR image of a rat with a tumor. Hyperpolarized pyruvate is taken up by the tumor and converted into lactate as measure of tumor metabolism (elevated aerobic glycolysis).*

# CENTER FOR INTELLIGENT ORAL DRUG DELIVERY USING NANO AND MICROFABRICATED CONTAINERS (IDUN)

**Leader**
Professor Anja Boisen

**Location**
Technical University of Denmark

**Period**
2015-2021

**Grant**
56 mil. DKK

Oral drug delivery is the preferred route of administration due to its minimal invasive nature and convenience for the patients. However, it has key challenges and limitations: (i) Many potent drugs like proteins and peptides (e.g. insulin) cannot survive the passage through the gastrointestinal tract. (ii) Release kinetics need to be controlled (time, location, amount). (iii) A large part of newly discovered drugs, such as HIV compounds, has low solubility and/or permeability. (iv) Many drug treatments require combined or simultaneous release of several compounds. (v) Amorphous drugs have enhanced solubility and dissolution rate. However, long-term stability is a challenge since the drugs recrystallize. The goal of IDUN is to explore micrometer-sized containers for oral drug delivery. The containers will act as small toolboxes where the interior can be designed with sub-compartments and a variety of bioactive agents (tools) will be loaded depending on the application. We will use the containers to: protect potentially labile active pharmaceutical ingredients, control release kinetics, enable adhesion to the intestinal mucosa, realize unidirectional release, facilitate combined or sequential release of several drugs, and stabilize drugs in their amorphous form.

*Arrays of micro-containers for oral drug delivery. Each square contains 625 micro-containers.*

# CENTER FOR BACTERIAL STRESS SURVIVAL (BASS)

**Leader**
Professor Kenn Gerdes

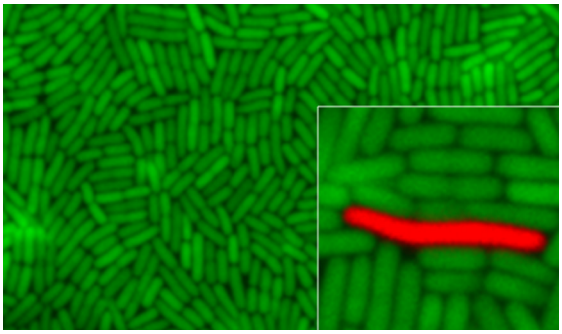
**Location**
University of Copenhagen

**Period**
2015-2021

**Grant**
50 mil. DKK

All bacteria, including major pathogens such as TB, MRSA, Salmonella, etc, form persistent forms with low frequency that can survive antibiotic treatment. In healthy individuals, the immune system eradicates these rare bacteria. However, in debilitated or elderly individuals, such surviving bacteria can generate the basis for chronic or relapsing infections.

We discovered that the intracellular regulatory molecule, (p)ppGpp, present in almost all bacteria, is the master regulator of the persistence phenomenon. The cellular level of (p)ppGpp is high in low fractions of growing bacterial populations (see the Figure) and these bacteria are resistant to multiple antibiotics and thus survive during chemotherapy. In the DNRF and Novo Nordisk Foundation Centre for Bacterial Stress Response and Persistence (BASP) at the Dept. of Biology, University of Copenhagen, we will study how bacteria control their levels of (p)ppGpp and how it allows them to survive many different types of environmental stresses, including antibiotics.



*Rapidly growing bacterial population (Green) showing one slow-growing, persistent (multidrug tolerant) bacterium with a high level of the second messenger guanosine tetra and pentaphosphate [(p)ppGpp]*

# CENTER FOR NEUROPLASTICITY AND PAIN (CNAP)

**Leader**
Professor, Dr. Med
Thomas Graven-Nielsen

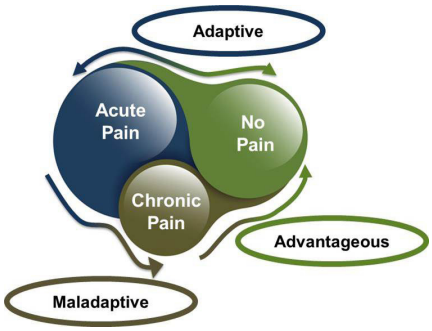
**Location**
Aalborg University

**Period**
2015-2021

**Grant**
60 mil. DKK

When an injury results in acute pain, the nervous system undergoes an adaptive neuroplastic response resulting in an increase in sensitivity. After some time, the pain neuroplasticity is normalized as the injury heals. In some cases, such neuroplastic processes fail to normalize during convalescence, and acute pain develops into chronic pain with hypersensitivity. The continuing pain after injury resolution is considered due to maladaptive pain neuroplasticity. In contrast, advantageous neuroplasticity permits the nervous system to cope with challenges such as maladaptive pain neuroplasticity to help returning to a pain-free state.

The Center will apply a biomedical engineering approach where new advanced pain provocation and probing platforms will be discovered and applied to reveal novel aspects of the human pain neuroplasticity. This will lead to experimental human models describing the unknown dynamic properties of pain neuroplasticity in humans. These models will be exploited to identify methods for promoting advantageous neuroplasticity in the human pain system.




*The hypothesized link between neuroplasticity (adaptive, maladaptive, advantageous) and pain conditions.*

# CENTER FOR CHROMOSOME STABILITY (CCS)

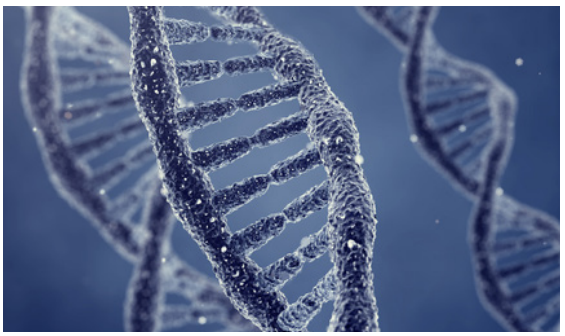
**Leader**
Professor Ian D. Hickson

**Location**
University of Copenhagen

**Period**
2015-2021

**Grant**
65 mil. DKK

The maintenance of chromosome stability is of paramount importance for the successful propagation of all species. A breakdown in chromosome maintenance is an underlying feature of several debilitating disorders in humans ranging from birth defects and some forms of neurodegeneration to cancer. In the Center for Chromosome Stability, we investigate the molecular causes and consequences of defects in chromosome maintenance. We have a particular emphasis on regions of the human genome that are intrinsically unstable due to their atypical structure disrupting successive rounds of DNA replication. We combine molecular/cell biological techniques with analysis of model organisms such as yeast and mice to define precisely how these ubiquitous 'enemies within' the genome undermine the integrity of chromosomes, and how their instability is normally counteracted. Our ultimate aim is to develop new preventative or therapeutic strategies for combating human diseases associated with chromosomal instability.



*The human genome has 'fragile' regions caused by an unusual underlying DNA structure.*

# CENTER FOR AUTOPHAGY, RECYCLING AND DISEASE (CARD)

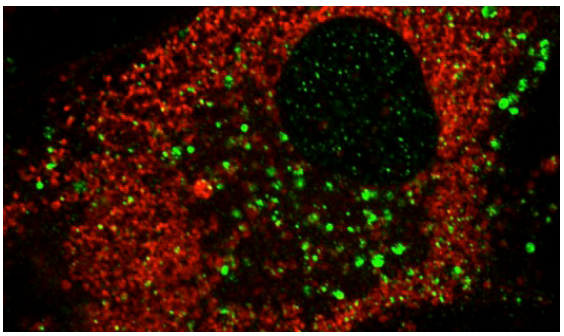
**Leader**
Head of Research,
Professor Marja Jäättelä

**Location**
Kræftens bekæmpelse

**Period**
2015-2021

**Grant**
50 mil. DKK

Cellular homeostasis is governed by integrated activities of energy-supplying organelles, macromolecule-producing factories and recycling pathways. As in our modern society, also in our cells, power supply, activity and waste disposal need to be kept in equilibrium and respond to immediate internal and external demands. Autophagy, a process of self-eating, is a key actor in this process. It ensures rapid removal of toxic materials as well as damaged or superfluous macromolecules and organelles through lysosomal degradation and recycling, thereby providing means for waste disposal and molecules for energy production and renovation. It also participates in essential cell-fate decisions concerning survival, malignant transformation and differentiation. CARD will combine complementary expertise at the Danish Cancer Society Research Center to elucidate the orchestration of cellular energy balance, damage control, recycling and autophagy with focus on autophagy regulating pathways and their crosstalk with other cellular processes.



*Accumulation of autophagosomes (green) and lysosomes (red) in cells with altered sphingolipid composition.*

# CENTER FOR PERSONALIZED MEDICINE OF INFECTIOUS COMPLICATIONS IN IMMUNE DEFICIENCY (PERSIMUNE)

**Leader**
Professor Jens Lundgren

**Location**
Rigshospitalet

**Period**
2015-2021

**Grant**
60 mil. DKK

The multidisciplinary centre at Rigshospitalet works from the hypothesis that across patient with impaired immune function, there is a common pattern of un-discovered risk factors explaining the variation in risk of infectious complications. Initially we aim at understanding the mechanisms explaining the variation in risk using a diverse set of methodologies, including pattern recognition from big data from routine care, studies of host and microbial genetics, imaging, and immunological characterization. The discovery phase will likely identify novel mechanisms of host defence, which will be used to characterize groups of immunocompromised patients and identify clusters of factors associated with comparable types of infectious complications. From this, we will formulate a series of immunodeficiency indices encapsulating the variation in risk for of infectious complications. The indices will be validated and used to personalise interventions aimed at reducing infectious complications.

*Personalization of interventions aimed at reducing infectious complications.*

# CENTER FOR STEM CELL DECISION MAKING (STEMPHYS)

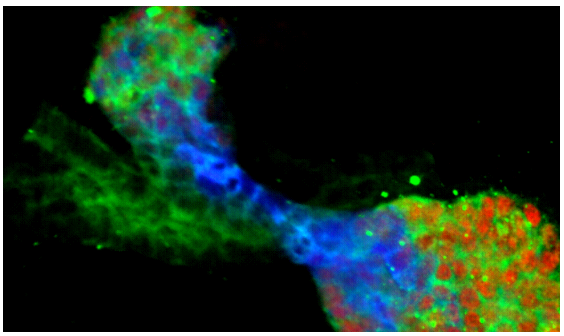
**Leader**
Associate Professor
Lene Broeng Oddershede

**Location**
The Niels Bohr Institute
University of Copenhagen

**Period**
2015-2021

**Grant**
60 mil. DKK

With the potential to produce specialized cells, stem cells are the holy grail of regenerative medicine; however, their exploitation is limited by an incomplete understanding of the mechanisms controlling their differentiation. Through interdisciplinary projects the StemPhys center joins forces of stem cell biology and theoretical and experimental physics to significantly progress our understanding of stem cell commitment. This endeavour will start a new era within quantitative stem cell biology and also has the potential to produce genuine medical advances. StemPhys combines unique stem cell lines with expertise in modelling, bio-imaging, and mechanical manipulation of living matter. Long-term goals include the development of methods to control and possibly reverse differentiation of stem cells. Our research on pancreatic progenitors, with the capacity to generate beta cells producing insulin, could produce new prospects for stem-cell based treatment of diabetes, and our work on liver progenitors could enhance drug development by providing hepatocytes for drug screening.



*Stem cell development into liver and pancreas.*

# CENTER FOR SILICON PHOTONICS FOR OPTICAL COMMUNICATIONS (SPOC)

**Leader**
Professor
Leif Katsuo Oxenløwe

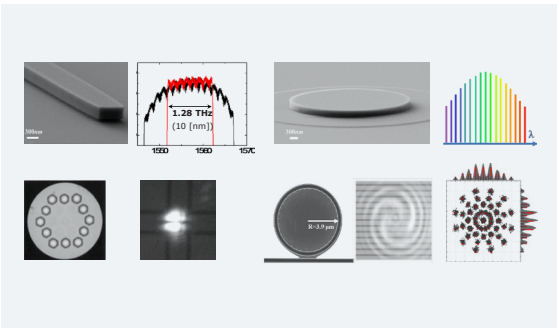
**Location**
Technical University of Denmark

**Period**
2015-2021

**Grant**
59 mil. DKK

This research centre addresses the optical communication infrastructures of the future. In an interdisciplinary approach, relying on physics, nonlinear optics, photonic communication technologies, information theory and advanced coding, we aim to find solutions to the major challenges of communication systems—the energy consumption and potential capacity.

We will explore optical signal processing in photonic wires for orders of magnitude improvements in bandwidth and energy efficiency, and conduct fundamental research on optical silicon chips and integration technologies addressing ultimate-capacity optical communications. We will explore spatially distributed data transmission for orders of magnitude higher data densities. We will explore information and coding theory for optimum spectral-efficiency. We will explore frequency comb generation for light sources and for unprecedented ultra-precise optical clocks and frequency references, and we will explore future quantum communication channels with impenetrable security."




*Advanced communication technologies based on silicon photonics.*

# CENTER FOR URBAN NETWORK EVOLUTIONS

**Leader**
Professor MSO
Rubina Raja

**Location**
Aarhus University

**Period**
2015-2021

**Grant**
65 mil. DKK

Becoming urban is widely recognized as one of the great turning points of history. The innovations, cultural entanglements and environmental exchanges afforded by urbanism led to social and material complexity, which make up the core of today's civilization. The complex stratigraphies of urban archaeology form a uniquely rich archive of this process. This evidence – the single most data-rich material archive of anthropogenic change in the last five millennia – remains vastly underexploited. The Centre for Urban Network Evolutions (UrbNet) will develop research that will offer comparison of convergent developments and determine how, and to what extent, past urban networks catalysed societal and environmental expansions and crises, potentially on a global scale. UrbNet pioneers a "High Definition" view of urban dynamics and constructs a leading research body, integrating scientific techniques with contextual archaeological and historical approaches. It aims to unleash new forms of data that are able to significantly test, challenge and revise narratives of particular urban sites as well as fundamental assumptions about trajectories, dynamics, and causal conditions of urbanization in the era of globally interlocking pre-industrial civilizations.

*Part of the Danish-German Northwest Quarter Jerash team discussing contextualised archaeological strategraphy in a water reservoir.*

# CENTER FOR CARBON DIOXIDE ACTIVATION (CADIAC)

**Leader**
Professor Troels Skrydstrup

**Location**
Aarhus University

**Period**
2015-2021

**Grant**
60 mil. DKK

The objective of the Carbon Dioxide Activation Center (CADIAC) is to unveil fundamentally new science for the activation of $CO_2$, thereby providing smart sustainable solutions for the exploitation of this molecule as a valuable C1-feedstock to high-value chemicals of industrial importance. Only through an international and multi-disciplinary effort can this ambitious objective be achieved, combining expertise from four research teams in catalysis, materials chemistry, surface chemistry and electrochemistry. We will generate materials not only displaying catalytic activity with high selectivity and efficiency properties for $CO_2$ conversion, but also materials that can absorb $CO_2$, thus assuring a sufficiently high "concentration" of $CO_2$ close to the catalyst. By merging the worlds of homogeneous catalysis with surface and materials science, we will be able to identify more advanced systems, which through optimized and controlled catalysis, transport processes and product formation, are able to deliver the desired high-value products in a sustainable manner. It is our goal to change the perception of $CO_2$ as a problematic combustion product to a valuable resource, which is essential for creating an energy and resource efficient society with a small carbon footprint.

*Two-chamber system employed for exploiting $CO_2$ as a valuable C1-building block for pharmaceutical synthesis*

# CENTER FOR MUSIC IN THE BRAIN (MIB)

**Leader**
Professor Peter Vuust

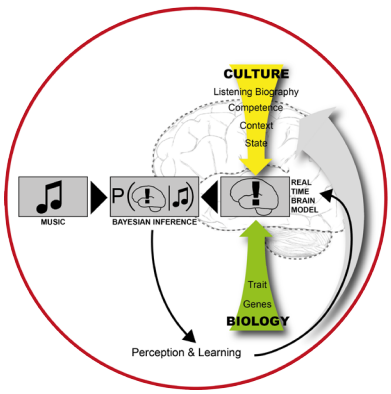
**Location**
Aarhus University,
Royal Academy of Music
Aarhus/Aalborg

**Period**
2015-2021

**Grant**
52 mil. DKK

The Danish National Research Foundation's Center for Music In the Brain (MIB) is an interdisciplinary research center aiming at addressing the dual questions of how music is processed in the brain and how this can inform our understanding of fundamental principles behind brain processing in general. The center employs state-of-the-art scanning methods (MR, fMRI, MEG, EEG, PET) and behavioral measures.

The MIB center is a collaboration between Aarhus University (AU) and The Royal Academy of Music (RAMA) placed at AU. The center is based on four strands of research in music and the brain: Perception, Action, Emotion and Learning. With a strong foundation in music practice and theory at the highest level, and a focus on clinical application of music, MIB combines neuroscientific, musicological and psychological research in music perception, action, emotion and learning, with the potential to test the most prominent theories of brain function, and to influence the way we play, teach, use, and listen to music.




*Predictive coding of music: Experiencing and learning music takes place in a dynamic interplay between build-up and relief of tension in rhythm, melody, harmony, form and other intra-musical features on one side (predictable music structures) and the predictive brain on the other.*

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

T +45 3318 1954
F +45 3315 0626
E dg@dg.dk

www.dg.dk

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