



UNIK-Synthetic Biology 2009-2014

Establishing Synthetic Biology as a Strategic Research Area at University of Copenhagen

Final report 2014



Preface

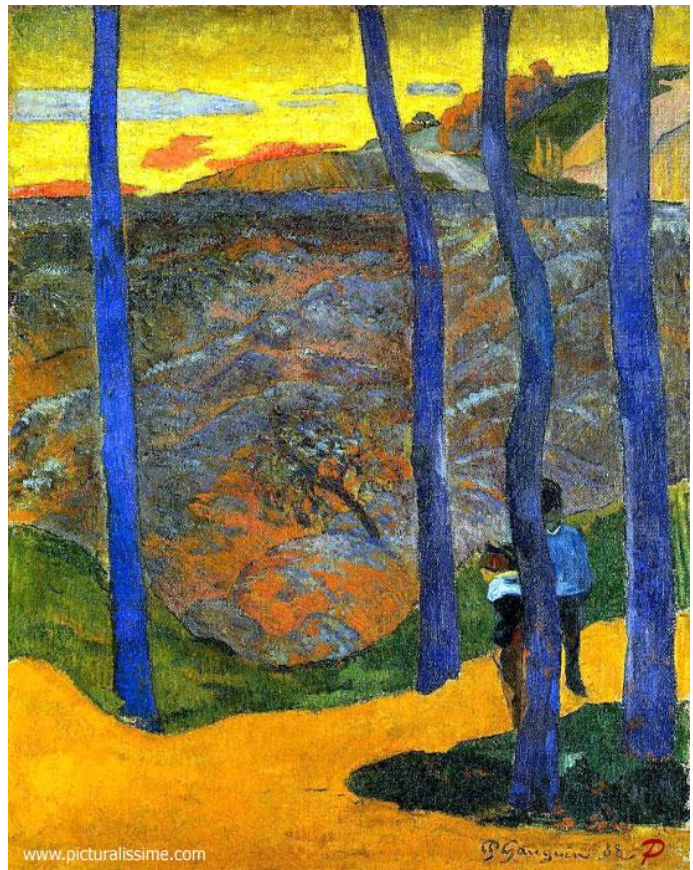
Reflections

In 2008, Thomas Bjørnholm, Kell Mortensen, Ulrik Gether and I set out to explore the combination of our respective fields, i.e. Nano-Science, Biophysics, Neuropharmacology and Plant biochemistry within the scope of Synthetic Biology - the emerging field of synthetic biology that combines science and engineering to construct and build biological systems with novel functions for the benefit of society. In this fertile ground, the exploration of uncharted potentials of the intersections of our fields set our hearts and minds racing and teaming with blue sky research ideas.

In 2009 University of Copenhagen was awarded the prestigious UNIK grant by The Ministry of Science, Technology and Innovation based upon our application and Center for Synthetic Biology was launched. The research initiative was established on the integrated accomplishments of research groups from the areas of nano-science, neuroscience and pharmacology, biophysics, plant biology and philosophy. There is no doubt that the integration of synthetic biology as a strategic research initiative at University of Copenhagen has been both timely and foresighted. The University harbors a rich and resourceful group of some of the world's most excellent scientists in this emerging and exponentially growing field of converging science. Very few of the participants had collaborated in such a large-scale cross-disciplinary and –cultural environment before the establishment of the UNIK Center for Synthetic Biology. Within the 5 year time frame of the UNIK-Synthetic Biology initiative numerous cross-disciplinary projects have turned out to be highly successful as documented by the informative list of publications as well as a well-versed, strategic and ambitious research community with international impact. It is now a fully unfolded prosperous and dynamic collective that moreover has grown with an extended group of ethics, legal and communication scholars at Center for Synthetic Biology at University of Copenhagen.

Thank you for entrusting us with the means to take upon us this highly gratifying and prosperous journey.

Professor Birger Lindberg Møller
Director of Center for Synthetic Biology
October 2014



Paul Gauguin: Blue tree trunks 1

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CHAPTER 1: INTRODUCTION

The purpose of UNIK-Synbio

With the clear aim of becoming one of the first Universities in Europe to launch a new world-class research, technology and education program on Synthetic Biology, The University of Copenhagen initiated Center for Synthetic Biology based upon the UNIK grant. The scientific objective of the proposal was to develop insights, tools and technologies for preparing and characterizing bio-inspired systems with tailor-made functions. The program focused on understanding how such systems are organized, and on learning to build similar systems by combining functional biological modules in new teams. With a unifying focus on membrane proteins, the research focus was on membrane proteins which are essential to basic processes in almost all living systems such as cellular signaling, photosynthesis or the maintenance of electrochemical gradients across cell membranes. The focus would provide the scientific basis for applications such as personal medicine, sustainable energy production, plants for the future, and molecular bioelectronics.

The following report provides an extended and more comprehensive reporting on the successes of the UNIK-Synbio initiative at University of Copenhagen based on previous reportings to the Site Visit Panel of UNIK-Synbio and the Ministry of Science, Technology and Innovation.

The Team of Principal Investigators

It requires a broad multidisciplinary team to launch a competitive research initiative in Synthetic Biology. Accordingly, the project has brought together a strong team of internationally highly recognized scientists in the key disciplines: Chemistry, Nano-science, Molecular Plant Biology, Molecular Neurobiology, Biophysics and Philosophy¹.

¹ Due to the fusion of Faculty of Life into Faculty of Science, the initial 4 faculties taking part in UNIK-Synbio is now 3. Furthermore, in the Steering Group: Thomas Bjørnholm was appointed pro-vice-chancellor of UCPH in 2010. His predecessor as Head of the Nano Science Center Morten Meldal was appointed Lighthouse Professor at Dept of Chem in 2013. The task is now undertaken by the new head of the Nano-Science Center, Bo Wegge Laursen.

Principal investigators

Faculty of Science

Department of Plant and Environmental Sciences

Birger Lindberg Møller (Chair, SG)
Seong W. Yang
Björn Hamberger
Poul Erik Jensen
T. Günther-Pomorski

Department of Chemistry

Bo Wegge Laursen (Steering Group)
Marite C. Gomez
Karen L. Martinez
Dimitrios Stamou
T. Vosch

Niels Bohr Institute

Kell Mortensen (Steering Group)
Lise Arleth
Jesper Nygaard

Faculty of Health

Department of Neuroscience and Pharmacology

Ulrik Gether (Vice Chair, Steering Group)
Claus J. Løland
Søren G. Rasmussen

Faculty of Humanities

Department of Media, Cognition and Communication

Sune Holm

The community

Surrounding the Principal Investigators are a community of almost 200 bachelor, Master and PhD-students as well as postdocs that have all for longer or shorter periods of time participated, been educated and have contributed to the Synthetic Biology community at University of Copenhagen (see appendices C and D).

Vision and mission of Center for Synthetic Biology at UCPH

As a guiding principle for UNIK as well as for the establishment and continuation of Center for Synthetic Biology; the vision as well the mission for the integration and prosperous development of synthetic biology at University of Copenhagen has been formulated by the Steering Committee.

The Vision of Center for Synthetic Biology is to make synthetic biology an essential component of a prosperous Bio-based Society through scientifically groundbreaking and ethically sound science made available for the global community, for education and societal growth.

In achieving this, our mission is to:

- **Deliver** world class synthetic biology research and education
- **Maintain** and strengthen a prosperous cross-disciplinary working environment
- **Establish** synthetic biology as a key focus area at the governmental, academic, industrial and political levels, ensuring Danish leadership in the development of synthetic biology as a key component of a prosperous Bio-based Society
- **Engage** in public dialogue
- **Promote** an ethically sound approach to synthetic biology



Strategic approach to obtain mission

To gain as much short and long term impact as possible from the availability of the UNIK grant, Center for Synthetic Biology has focused its efforts on:

- Producing world class synthetic biology research and education
- Establishing infrastructure and core facilities
- Developing a strong cross-disciplinary collaboration platform within the Center, within the University of Copenhagen as well as at the national and international level
- Strategic endeavors to secure additional and future funding possibilities, nationally as well as at the EU-level
- Strategic and concrete endeavors to further strengthen and continue industrial interest and collaborations
- Strengthening of the public dialogue taking into consideration the development of citizen science and the accompanying crowd accelerated innovation that need to be captured to spur interest in natural sciences and engagement of the general public in science matters
- Continued focus on ethical aspects of synthetic biology both in public dialogue and in scientific development.

CHAPTER 2: PUBLICATIONS AND IMPACT

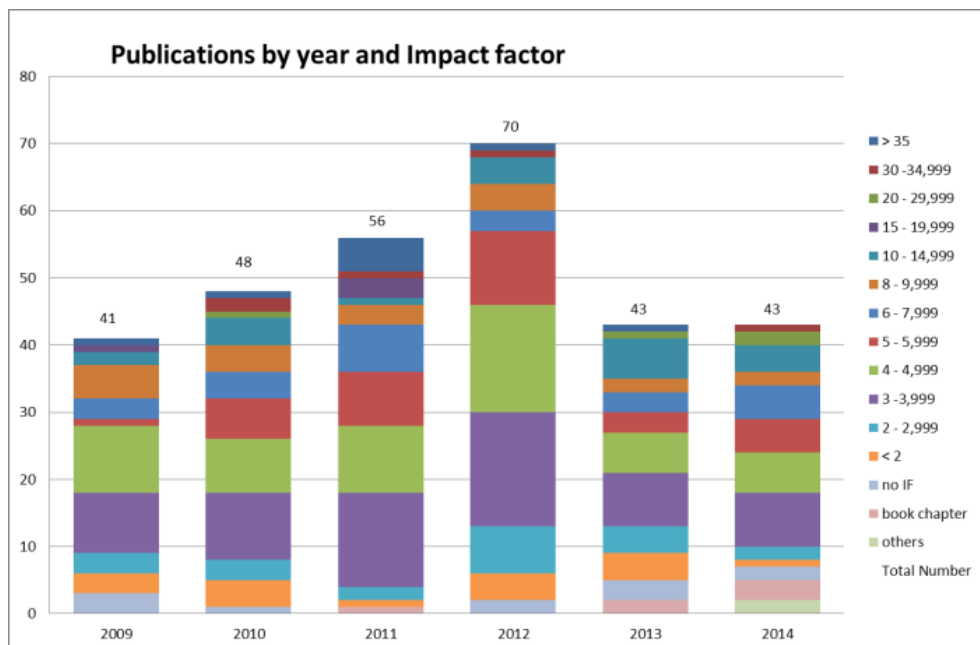
Publications

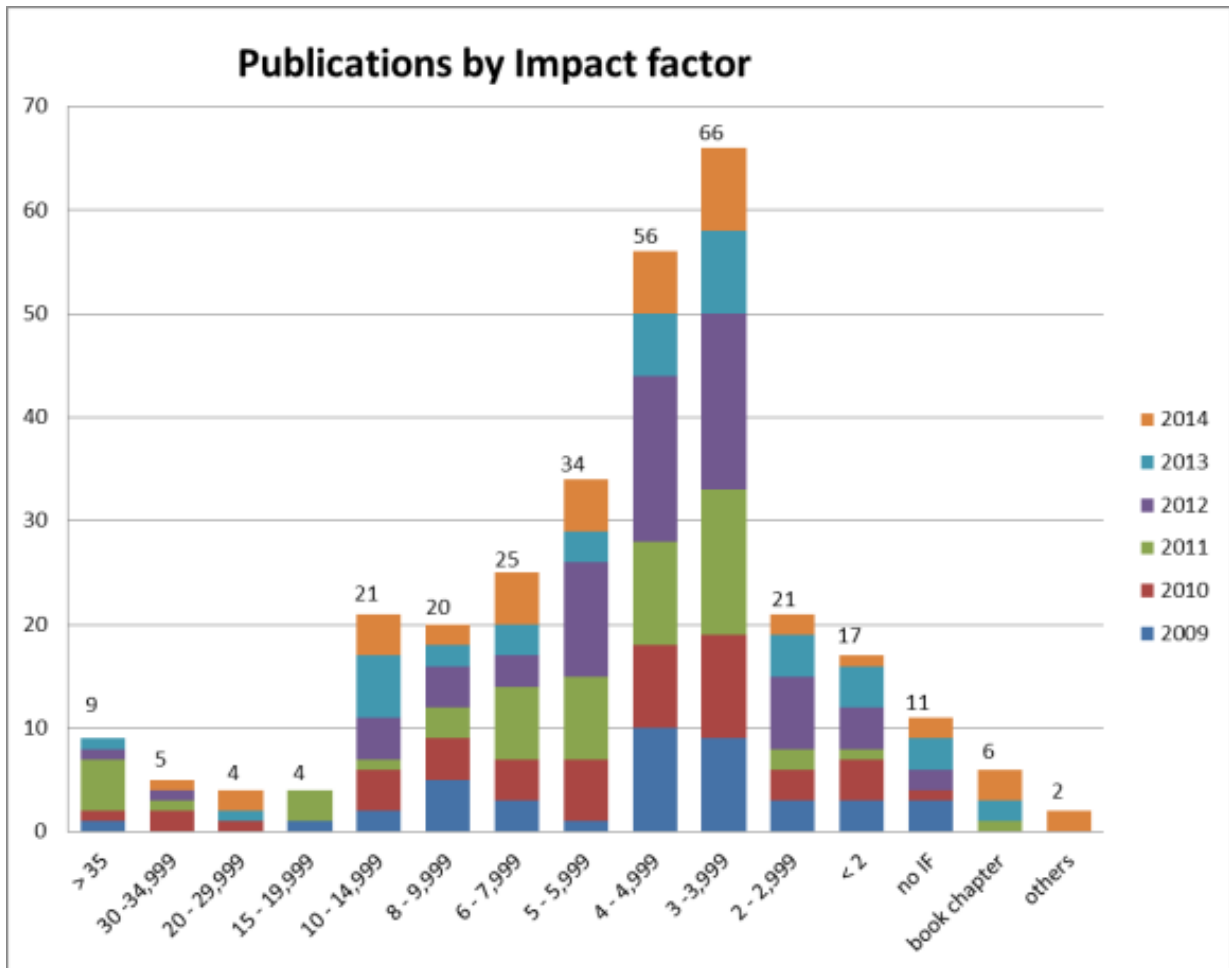
Numerous cross-disciplinary projects have turned out to be highly successful as documented by the list shown below of peer reviewed research publications in the period of 2009-2014.

Publications by Impact factor

More than 40% of the articles have been published in high-impact journals with >5 in impact factor (IF), of these 18% in very high-impact journals of above 10 in IF and with publications each year in the absolute highest IF of >35, except 2014 as of yet.

Impact F	No.	in %
> 35	9	3
30 - 34,999	5	1,7
20 - 29,999	4	1,3
15 - 19,999	4	1,3
10 - 14,999	21	7
8 - 9,999	20	6,6
6 - 7,999	25	8,3
5 - 5,999	34	11,3
4 - 4,999	56	18,6
3 - 3,999	66	22
2 - 2,999	21	7
< 2	17	5,6
no IF	11	3,7
book chapter	6	2
others	2	0,7
Total	301	100,1





Publication rates have been steadily increasing from 2009-2012 with a decrease in 2013 which is explained by natural fluctuations in scientific output as well as several encounters of challenges in the peer review processes in terms of cross-disciplinary peer-review with editorial competences and structure lacking in overview of areas and techniques included. Challenges were overcome by strong engagement with editors resulting in delayed but successful publications.

Publication List

2014

1. Bonde, S., Buch-Manson, N., Rostgaard, K.R., Andersen, T.K., Berthing, T., and Martinez, K.L. Exploring arrays of vertical one-dimensional nanostructures for cellular investigations. *Nanotechnology* 25, 362001-362001, doi:10.1088/0957-4484/25/36/362001 (2014).
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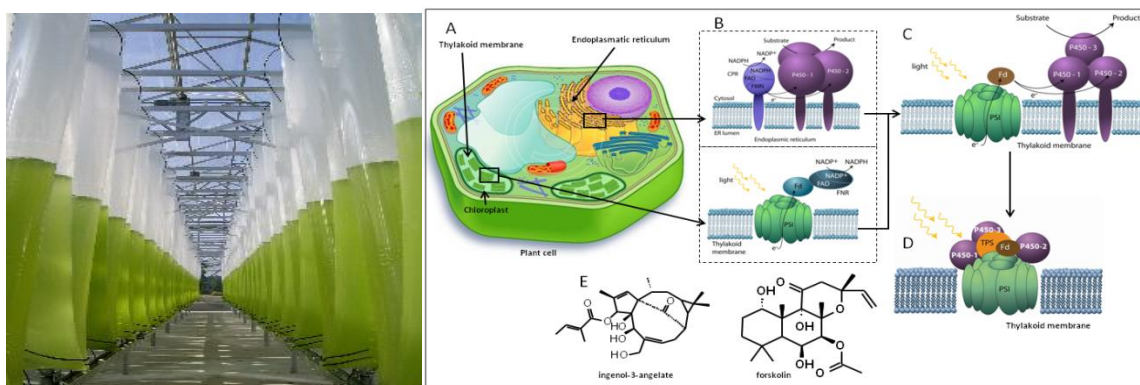
CHAPTER 3: SCIENTIFIC ELEMENTS

Successful research initiatives

The most successful and promising research initiatives within the center have, as demonstrated in the publication list, had great impact on the scientific community. A closer look at the achievements follows below:

Light Driven Production of High Value Compounds in Green Contained Systems

- The research initiatives to develop light driven cell factories to produce compounds for the food and pharmaceutical industry, as well as fine and bulk chemicals for the benefit of society in a future of limited resources and as a feed stocks for semi-synthetic chemistry.



Breakthroughs and advances have been made in developing cyanobacteria as well as mosses as robust and stable cell factories.

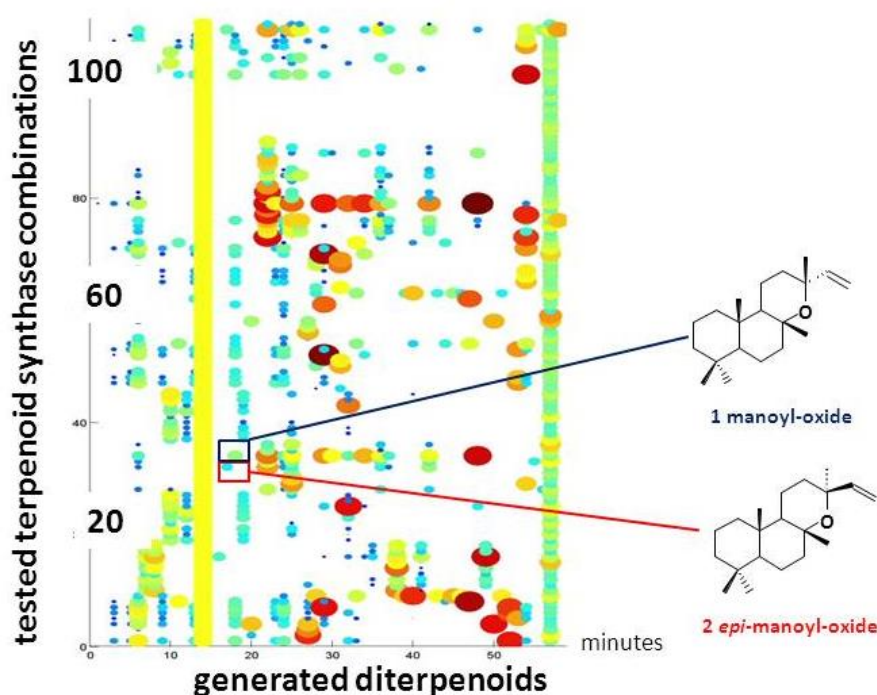
Transient expression in tobacco has proven highly useful as a fast test system. In tobacco, the entire biosynthetic pathway for a bio-active natural product has been introduced by chloroplast transformation. We have managed to incorporate P450 enzymes directly in the photosystem I complex in a functionally active form using the small subunits of photosystem I as membrane anchors. Focus is on the design and engineering of “green” carbon dioxide and solar energy driven, environmentally benign and contained production systems for production of a large variety of desired compounds.

Light driven synthesis of complex bioactive natural products using the power of combinatorial biochemistry is an important aspect of this work. The design of the cell factories is based on a coherent interplay of synthetic biology and synthetic chemistry.

Combinatorial biochemistry offering new-to-nature diterpenoids

Key enzymes involved in the biosynthesis of diterpenoids are the terpenoid synthases (TPS) building the complex core structures and the cytochrome P450 monooxygenases decorating the core structures in a regio- and stereospecific manner.

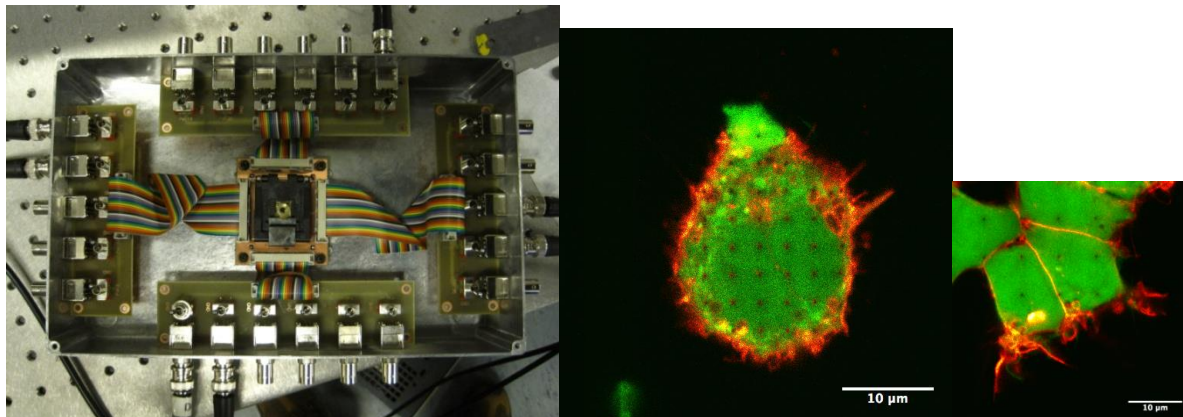
Elucidation of the biosynthetic pathways is carried out using combined approaches encompassing identification of biosynthetically active tissues or cell-types in the medicinal plant producing the target diterpenoid coupled to metabolite profiling, proteomics and transcriptomics and structural identification based on LC-MS-MS and GLC-NMR. Transcriptome analyses of a number of medicinal plants have provided a thorough understanding of the TPSome and P450ome of medicinal plants as independent routes to interesting genes candidates.



A number of interesting target molecules have been identified with forskolin, triptolide and ingenol-3-angelate as the key target compounds. A breakthrough has been the discovery that combinatorial biochemistry based on co-expression of terpenoid synthases from different medicinal plant species may be used as a new approach to further enlarge the structural diversity of diterpenoids and to produce new-to-nature diterpenoids, many of which would be expected to have highly interesting pharmaceutical properties. Five patent applications resulting from the work have been filed and two are under submission. Focus on patenting these promising approaches and results has somewhat delayed publication of the results in scientific journals.

Nano-machines and interaction with biological systems

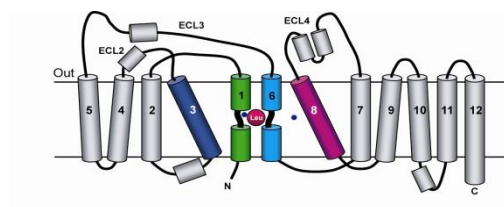
The research initiatives on the interaction of nanostructures with biological systems to interface proteins and nanowires for fabrication of nanowire-based field-effect transistors (FETs) can be used as ultra-sensitive and label-free biosensors for detecting protein–protein interactions.



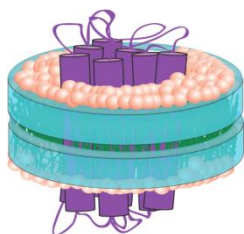
A method to fabricate inexpensive and transparent nanowire impalement devices has been invented. By employing a novel process, the nanowires are transferred to a transparent, cell-compatible epoxy membrane. Cargo delivery and detailed cell-nanowire interaction studies turned out to be highly challenging because the cell plasma membrane was found to tightly wrap the nanowires, while cell membrane penetration was not observed. Following careful optimization of several steps in the procedure, successful insertion of nanowires into the cells has now been accomplished. The presented device and other developed model systems were utilized to optimize conditions for simple and versatile impalement delivery systems in order to obtain maximum response and signal-to-noise ratios when measuring ligand–protein and protein–protein interactions. The robust sensing systems achieved represent an important breakthrough in the advancement of the use of custom designed nanowire arrays for studies within cell biology, the interfacing with living cells and the study the effect of membrane curvature. The research initiatives within the emerging field of bionanoelectronics are supported by new equipment acquired by the UNIK grant, which provides state-of-the-art infrastructure to be fully exploited.

Fundamental research on membranes

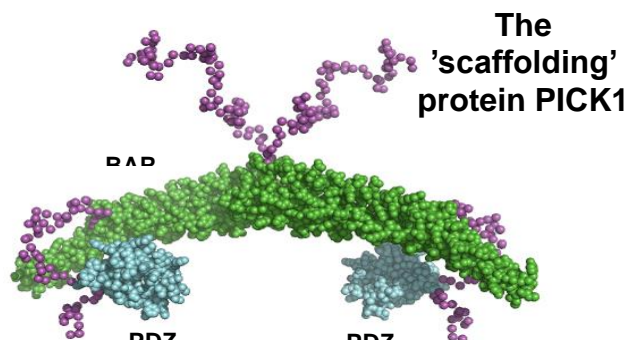
The research initiatives focusing on fundamental research on receptors and membrane transporters as well as scaffolding and signaling proteins have provided major breakthroughs.



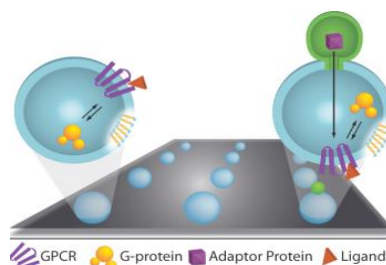
The leucine transporter LeuT



Reconstitution into nanodisks



The 'scaffolding' protein PICK1

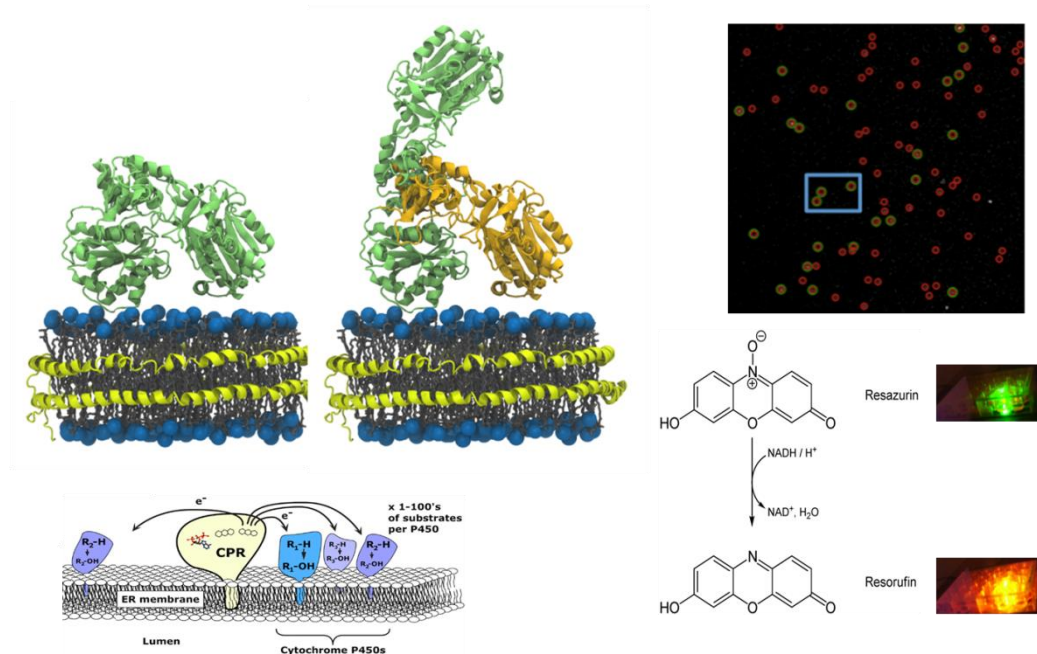


Reconstitution in single liposomes and immobilization on surfaces

Pioneering introduction of new types of amphiphilic detergents for membrane protein solubilisation and structural stabilization using nano bodies have resulted in unprecedented detailed structural elucidation of the crystal structures for several important receptors including the $\beta 2$ adrenergic receptor ($\beta 2AR$) in the presence and absence of agonists. Structural elucidation of receptor complexes trapped in different conformations based on X-ray structural analysis opens new avenues for drug development, screening and diagnostics for CNS related disorders such as stroke, Alzheimer's, Parkinson's, Schizophrenia, depression and addiction. Breakthroughs have also been made with respect to understanding the molecular organization of signalosomes in neural signal transduction and with respect to the elucidation of the mechanisms vital for formation and stabilization of tubular subdomains that mediate cargo recycling and generate and organize the tubular endosomal cellular network in vivo. The role of scaffolding proteins in clustering and recycling rates are being elucidated.

Single Molecule Studies

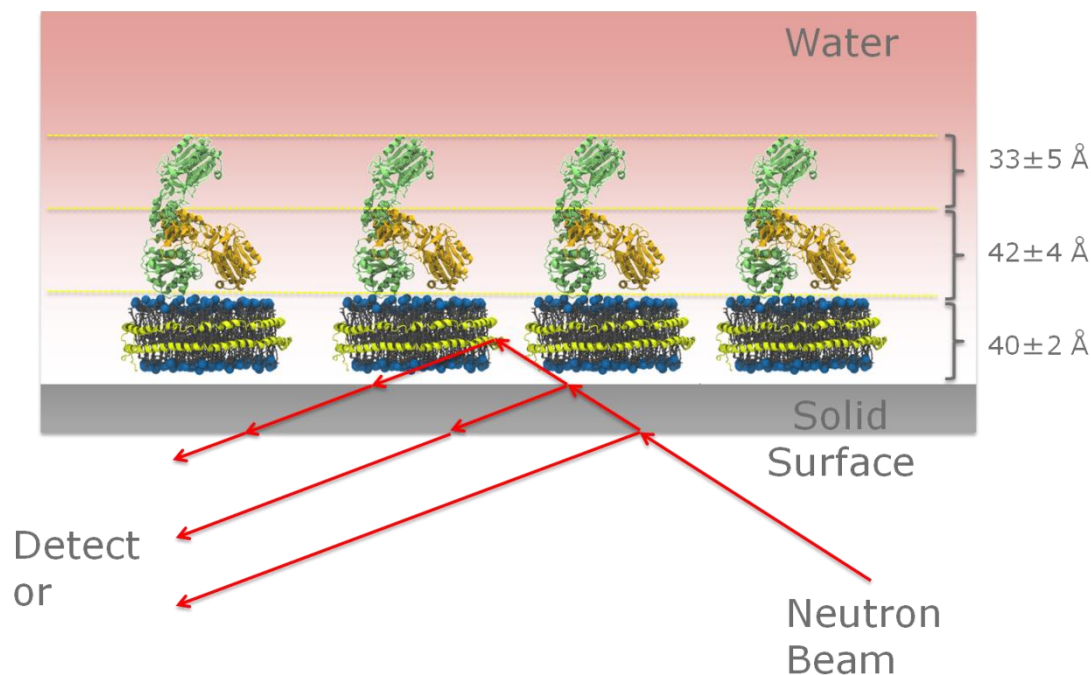
The single molecule studies are based on the technology platforms established at the Nano Science Center. Several membrane proteins including receptors, transporters and the electron donor protein to cytochrome P450s are now being studied at the single molecule level mainly using fluorescent technologies.



All experiments at the single molecule level are performed in near native conditions following incorporation of the proteins into nanodiscs or liposomes or using styrene-maleic acid particles. Single molecules kinetics, conformational changes and domain motion following binding of substrates, inhibitors or effectors as well as the role of membrane curvature on protein- protein interaction and protein complex formation are monitored. Allosteric regulation of enzymatic activity forms the basis for controlling a plethora of vital cellular processes and is proposed to primarily operate via conformational selection. We have now for the first time managed to directly monitor the allosteric regulation of the enzymatic activity of monomeric enzymes at the single molecule level. Single stochastic catalytic turnovers of the monomeric metabolic enzyme were monitored while titrating its proximity to a lipid membrane that acted as an allosteric effector. The single molecule measurements revealed the existence of discrete binary functional states that could not be identified in macroscopic measurements due to ensemble averaging.

Advanced biophysical characterization

The research initiatives on advanced application of biophysical methods to study and characterize key components of interesting biomolecular systems in a near-natural environment i.e. combining excellence in biology with excellence in biophysics. Focus is on the development and application of a different range of state-of-the-art experimental biophysical methods on biological systems, whereby the knowledge gained advances biological understanding in important areas.



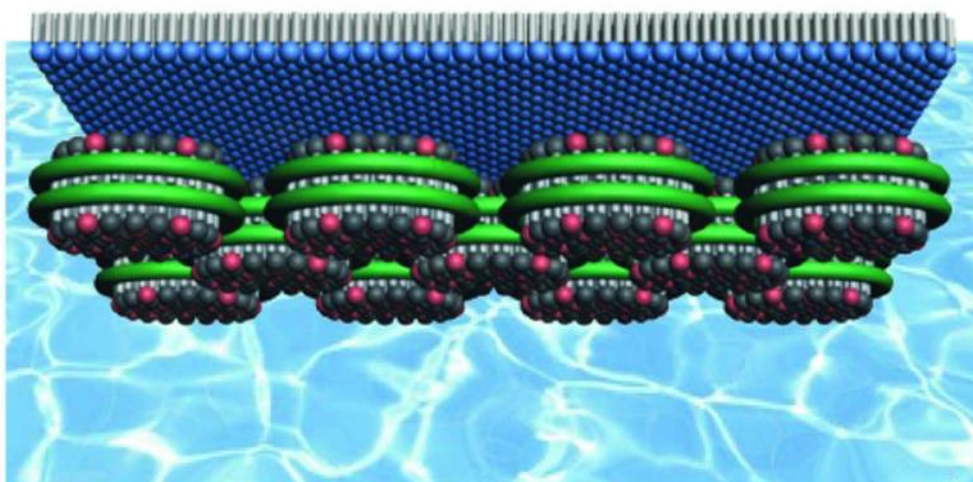
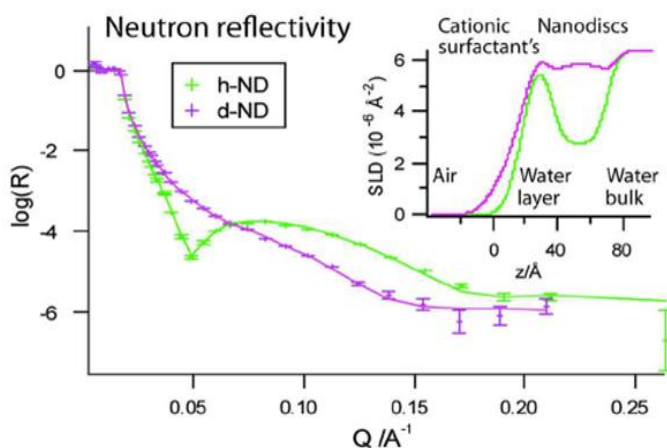
Intimate collaboration between biologists, chemists and medical scientists is a key parameter for success. Biophysical measurements on membrane proteins pose numerous challenges and render it necessary to have a range of methods available, each offering different experimental advantages. The membrane proteins of interest are incorporated into nano discs or liposomes. Structural information based on neutron reflectivity studies has been obtained following successful alignment of a well-defined two-dimensional layer of nano-discs at the air-water interface. Quartz crystal microbalance technology has also been established. The latter approach requires small amounts of biological material and is robust towards minute sample inhomogeneities. Initially, the use of scattering techniques proved difficult due to presence of oligomeric forms of the membrane proteins. These issues have been solved by introduction of a free flow electrophoresis step to get monodisperse nano-disc preparations. New microscopes and spectrophotometers have been designed and constructed to provide unprecedented detailed analysis of the biological systems studied. A fast DNA-silver cluster based analytical procedure has been designed to enable fast simultaneous quantification of specific microRNAs.

Development of the use of nanodisc and liposome platforms

in combination with scattering methods, to relate the function of membrane proteins to their organization and structure in natural like environments. The structural information is used to understand self-assembly processes in biology, to genetically modify membrane proteins to improve their catalytic efficiency and more importantly, to change the specificity of their function e.g. by modifying their ability to engage in formation of enzyme complexes (metabolons). Isolation of monodisperse nanodisc-reconstituted membrane proteins using free flow electrophoresis provided a breakthrough for successful use of the scattering technology. "Stealth" nano discs were prepared using lipids and scaffolding proteins labeled with stable isotopes and will enable improved resolution images of the incorporated membrane proteins by neutron diffraction studies.

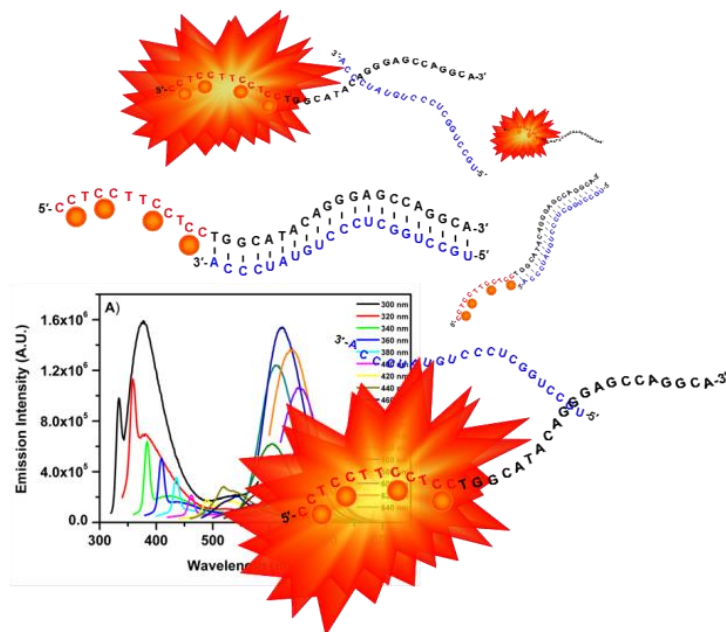
Two-dimensional monolayer structural elucidation of nano-discs

The method developed for structural elucidation by neutron reflectivity studies based on the alignment of a well-defined two-dimensional monolayer of nano-discs just below a surfactant film at the air-water interface or following adsorption of the nano discs at a solid surface. These approaches require small amounts of biological material and are robust as demonstrated in the first joint studies on cytochrome P450 reductase.



The construction of new microscopes and spectrophotometers

designed to provide unprecedented detailed analysis of the biological systems studied both with respect to the identification and structural distribution of organic molecules in biological materials from animals and plants. The silver cluster based fast analysis of specific microRNAs is an important patented outcome that offers low cost early-diagnostics of serious diseases such as a number of different cancer types.



Ethics of synthetic biology

Philosopher Sune Holm's research on potential ethical dilemmas related to the research projects in the center has been presented at the internal workshops of the center and in public lectures, as well as in research papers.

During the grant period a close relation has been established with philosopher Sune Holm who has undertaken seminars and discussion groups about ethics for the natural scientists as well as for the public. Sune Holm also engages with the iGEM students (see page 47)

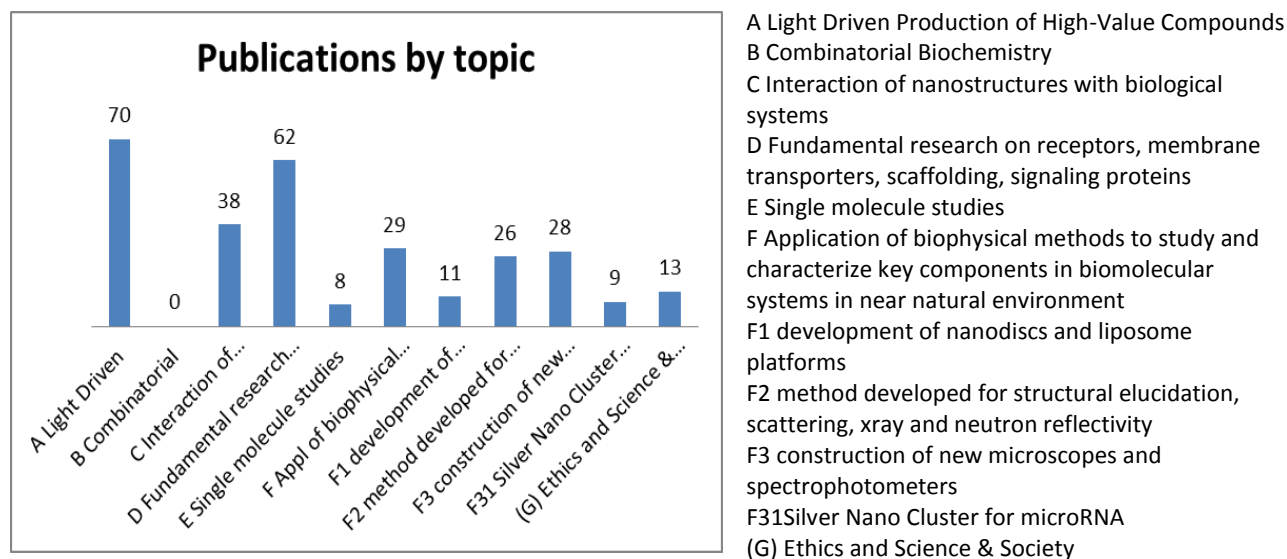
An initiative to integrate the ethical dimensions of synthetic biology even closer with the practicing scientists – Ethics Discussion Groups – has now been initiated at the Center. Senior as well as junior scientists participate in these groups based on reciprocal exchange. Among other things, the outcome has contributed to the enlargement of the ethics group and inclusion of both communication and legal scholars in the bioSYnergy project.

The Center has contributed extensively to the 2011 **report on synthetic biology by the Danish Council of Ethics and the Technical Advisory Board**.

Ethics continue to be a key focus area for the center and are now being integrated into our Responsible Research and Innovation approach in the bioSYnergy project.

Publication demography of the core scientific areas

The demographic profile of the publications in terms of focus areas for the UNIK initiative clearly indicates the scientific success in the main areas of focus.

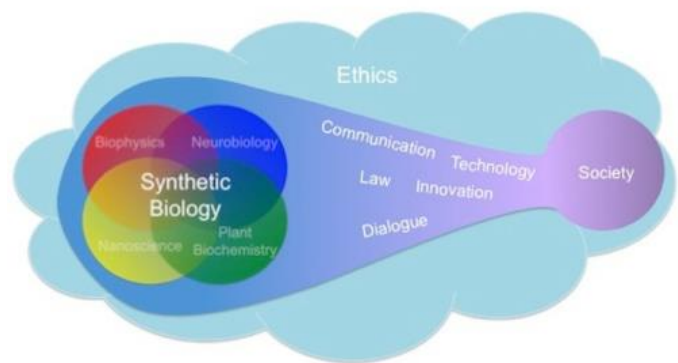


Future perspectives

The hallmark of the continued research at Center for Synthetic Biology is to elucidate the function of membrane proteins involved in key processes in biology. Membrane proteins are notoriously difficult to master, but we have world-class expertise within this area. By superimposing state-of-the-art plant- and neurobiology, nanotechnology and biophysics, we shall in leaps and bounds progress our work. In parallel, we shall implement a pioneering and innovative approach to a balanced socio-technological introduction and implementation of novel technologies by enhancing the existing cross-university synergetic collaboration to key scientific expertise from Humanities and Law Faculties. It is our ambition to demonstrate that proper integration of natural science, ethics, law and communication skills provides a means to successfully transform the knowledge obtained into major environmentally benign global footprints on industrial production and health, and may thereby help to provide research based solutions to alleviate some of the global challenges we are facing. In Europe, such approaches have turned out only to be successful if accepted by the general public. Compared to other new technologies, synthetic biology may profit from the use of bottom-up principles, as exemplified by the bloom of bio-hackerspaces based on knowledge-sharing, and by the institutionalization of the BioBricks Foundation which facilitates open access to a large number of biological parts enabling the construction of devices with new functionalities upon assembly in new combinations. These open source based approaches may boost novel business models based on easier access to patent use and pooling of patents. However, complicated legal aspects in relation to IPR and regulations must be addressed and carefully evaluated, as outlined in our proposal. Once the legal and economic aspects of handling the ownership of open access science are solved, this approach will spur the further advancement of citizen science and crowd accelerated open innovation, which raises public awareness of the importance of science in the long term.

‘Plant power: the ultimate way to go green’ is the essence of this cross-faculty research initiative within synthetic biology. Ultimately, the research will provide a sustainable alternative to the fossil fuel-based and highly polluting production systems used currently. It is based on the “share your parts principle” enabling controlled construction of new devices and aims at designing a “plug-and-play” platform for solar energy driven synthesis of a multitude of different high-valuable compounds which have competitive edge and market potential for the future globalised bio-based society. This goal will be reached by transplanting the biosynthesis of these structurally complex molecules from the endoplasmic reticulum to the chloroplast where the process can be driven by the readily available solar energy based reducing power of photosynthesis.

Microalgae, mosses and plant cells are developed as new, sustainable and environmental benign production systems. Furthermore, embracing the fact that research based innovation for societal growth demands close dialogue with public, industrial and political stakeholders, we have established a novel and integrated bioethics and communications benchmark platform for making society and scientists equipped for constructive dialogue on new technologies and scientific social responsibility. This includes science mentoring of do-it-yourself citizen scientists. In addition, research into the challenges faced by synthetic biology in terms of intellectual property are being addressed. Solutions that will enable integration of the bottom-up and open access approaches of synthetic biology with the existing legal framework will be proposed at the national and international level. This will furthermore aid UCPH to achieve seamless technology transfer with strategic potential to SMEs and larger industry alike.



CHAPTER 4: CORE FACILITIES

Core Facilities and Continuation

Investment in infrastructure and the research facilities needed to undertake and develop the research within synthetic biology has been made possible with funds from the UNIK-grant and additional funding from external grants.

- **Three synthetic biology laboratories** have been established at two (former three) of the involved faculties at Copenhagen University, bringing together scientists from all contributing disciplines.
- Additionally, with the fusion of the LIFE and SCIENCE faculties and the subsequent movement of the biophysics group from the now former LIFE campus to the Niels Bohr Institute situated at the Nano-Science Center, an **additional laboratory** has been established for the now established **X-Ray and Neutron Science group** headed by UNIK Steering Group Professor Kell Mortensen.
- At KU-Science (former KU-LIFE), major funds (400 million DKK) have been set aside by the University of Copenhagen to establish **Copenhagen Plant Science Center** (10.000 m²) to be finalized in 2015-16. The prominent German plant scientist Dario Leister has been appointed Head of Copenhagen Plant Science Center with UNIK-PI Professor Poul Erik Jensen as Vice-Head. The Plant Science Center will contribute significantly to long-term sustainability of synthetic biology and key scientists can potentially continue projects at this new facility.



1: CPSC, Lundgaard & Tranberg Arkitekter

- **The Panum Tower** (appx 38,000 m²) at the Health Faculty to be finalized in 2015-16 will house the Molecular Neuropharmacology group headed by UNIK Steering Group Professor Ulrik Gether and provide access to state-of-the-art unique instrumentation as well.



2: The Panum Tower, CF Møller

- **The Niels Bohr Science Park** at the Science Faculty to be finalized in 2015 will provide excellent facilities for chemistry, physics and biophysics.



3: NBI Science Park, Rambøll

- The establishment of the **European Spallation Source (ESS)** materials research facility for scientific research using the neutron scattering technique under construction in Lund further ensures that development of unique biological systems to be studied at the facility is the key to benefiting from this new facility and to raise the international standing of the University of Copenhagen.

The X-Ray and Neutron Science group is deeply involved in a number of activities related to the emerging facilities: The neutron facility, the European Spallation Source (ESS), and its neighbour X-ray facility, MAX-IV; and at the European Free Electron X-ray Laser (XFEL) under construction in Hamburg (D). The group participates in design and simulation of instruments, possibility awareness projects, education (Kell Mortensen) and expert advice to ESS. UNIK-appointed Physics Professor MSO for Synthetic Biology Lise Arleth is participating in the Scientific Advisory Council for ESS. Kell Mortensen leads the Danish Neutron Scattering Society, DANSSK and is board member of the European Neutron Scattering Association, ENSA.



4: ESS, Henning Larsen Architects

CHAPTER 5: EDUCATIONAL ACHIEVEMENTS

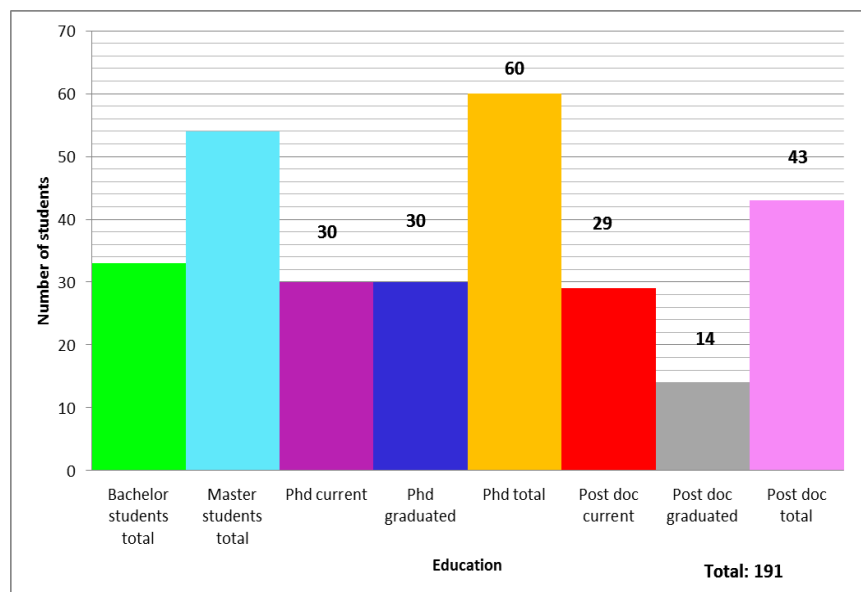
Educating for the future

Extensive impression on the next generation of synthetic biology scientists have been attained by the Center. In order to initiate, establish and implement a long-term embedment of synthetic biology in the educational curriculum of the UCPH, initiatives on both MSc and PhD-level have been undertaken

Education of cross-disciplinary and cross-faculty PhDs and Postdocs is a core output of the UNIK grant. The merging of competences brought into the projects from the different faculties has enabled an approximation of the participating faculties' research portfolio.

- **PhD projects:** A total number of 60 PhD projects have involved Synthetic Biology. The UNIK grant has co-funded more than PhD-projects with supervision by scientists of Center for Synthetic Biology accompanied by 33 closely associated PhD projects unfunded by UNIK, but scientifically within the same realm. Currently, 30 of these have graduated, 33 in finishing stages.

- **Post Doc projects:** 43 postdocs have worked on Synthetic Biology during their postdoc, 29 of which have now moved on to other employments to further advance their career. 14 are still following their fellowship



- **Bachelor and Master Students:** 54 Bachelor and 33 Master students projects have been supervised by scientists of the Center for Synthetic Biology.

- **Summer Schools:** 2 Synthetic Biology Ph.D.-Summer Schools have been established appx 30 Danish as well as European PhD-students participating in the five-day courses in the summers of 2011 and 2014.



A M.Sc. course in theoretical and experimental Synthetic Biology (UNIK Synthetic Biology) has been established at KU-Science (former KU-LIFE) since 2013, with contributions and active participation of *all* key scientists of the Center for Synthetic Biology Research Committee. The course is closely supervised and measures to ensure knowledge capture of the synthetic biology curriculum are being undertaken, including motivating the students to attend classes and laboratory projects, meet the high expectations and to further improve

the course based on the experiences gained. An important outcome is that the course has turned out to be an excellent platform as a point of departure for recruitment of biology, biochemistry, molecular biomedicine and nanoscience students for interdisciplinary master thesis projects.



Empowering the next generation of students: Participation in the iGEM (International Genetically Engineered Machine) student competition for BA and MA students is now a well-established part of the center's work. In 2012 and 2013, teams have been supervised by associate professors, postdocs and PhD students of the UNIK center. As of 2013, structures to promote the competition on a wider scale, as well as facilitating the process, have been established including aiding the participating students with regards to fundraising and promotion of the project (See webpage). The 2014 team unfortunately had to be cancelled due to difficulties in meeting scientific marks in due time. However, efforts continue to promote and recruit the best students to enter the career-improving competition.



Dual PhD Degree Programs with Yonsei University, Korea, and University of South Australia, Australia, have been established.

An Agreement for Exchange of Post doctoral Researchers has been signed to strengthen the collaboration with Shanghai Institute of Biological Sciences, Chinese Academy of Science, Shanghai.

- **5 book chapters** have been contributed to the the slowly growing formal curriculum of global synthetic biology²
- **A 6 week Coursera online course** in Synthetic Biology is under development with scheduled release in 2015 with contributions from all senior scientists of the UNIK initiative. Globally, this will be the first course focused solely on synthetic biology on dedicated online platforms. The course will be offered globally and is expected to attract from 2-10.000 students. The evolvment of the course is aided by University of Copenhagen.
- **Education of CBS students** in the form of lectures, tutorials and advising the development of business plans for selected target diterpenoids as part of their courses in entrepreneurship have provided by members of the UNIK Center for Synthetic Biology.
- **Network of Young Synbio Investigators**
The community is further supported by the the Network of Young Synbio Investigators (NYSI) (see more p 54)

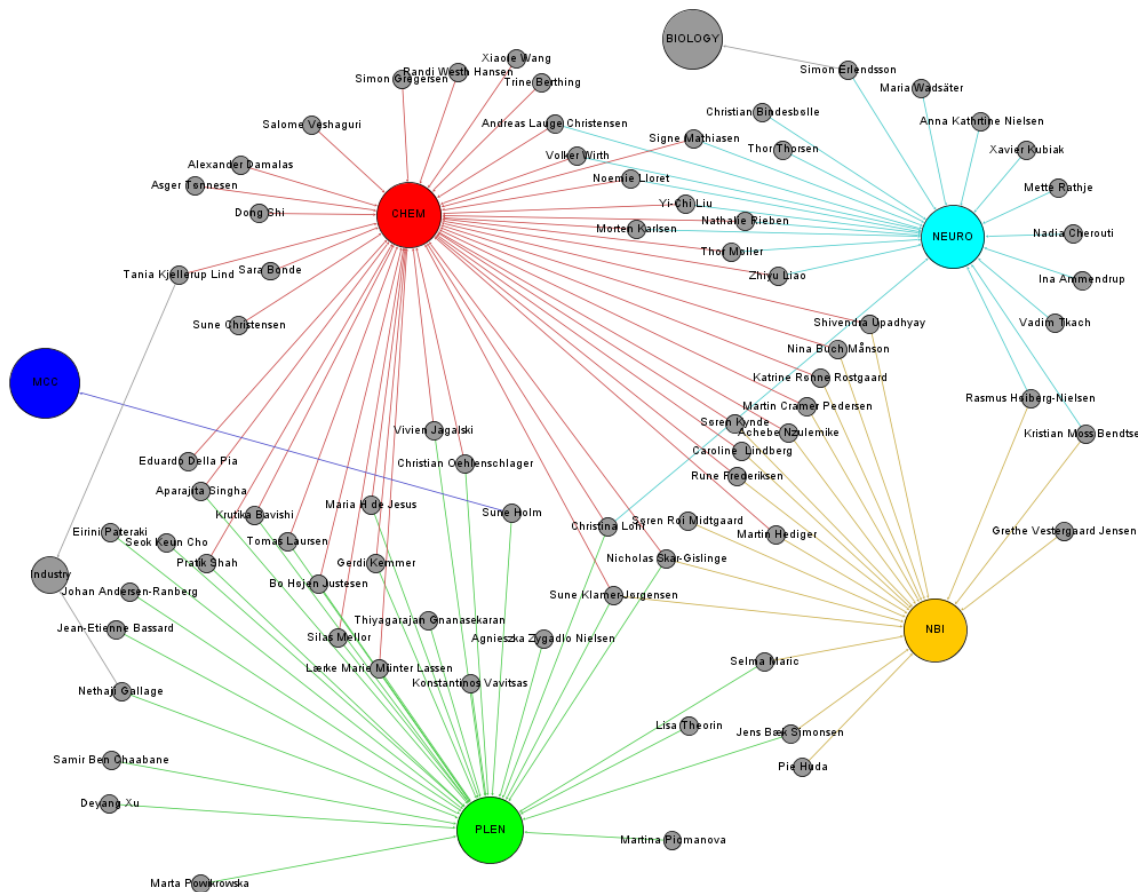
²Bak, S., Beisson, F., Bishop, G., Hamberger, B., Hofer, R., Paquette, S. and Werck-Reichhart, D.: Cytochromes P450. (2011)

Holm, S. H. "The Capacities, Interests, and Organisation of Artifactual Organisms" in Basel. J and Sandler R.L. (eds.) Ethical Issues in Engineering Biological and Ecological Systems. Plymouth: Lexington Books, pp 233-252 (2013)

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M. Zoonens, F. Zito, K.L. Martinez and J-L Popot "Amphipols: a general introduction and some protocols" In Membrane protein production for structural analysis (I Mus-Veteau, ed.), Springer : New York. (2014) in press
T. Kutchan, J. Gershenzon, B.L. Møller, D. Gang: Chapter 24 Natural Products (Secondary Metabolites). In: Biochemistry & Molecular Biology of Plants (Eds: Buchanan, Grussem, Jones) American Society of Plant Physiologists, 2.nd Edition, (2014)

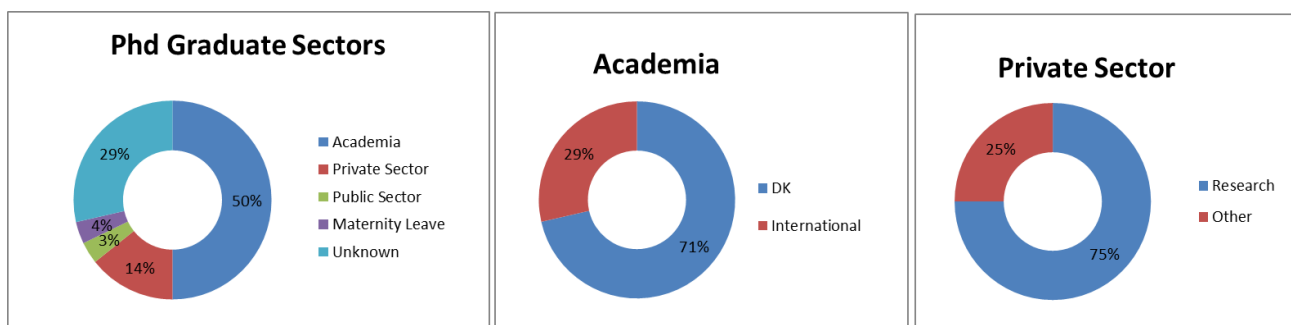
A. Glieder, S. Panke, A. Becker, S. Gaisser, A. Kresmer, T. Noll, J. Ritzerfeld, R. Takors, W. Weber, B.L. Møller, R. Gil, M. Isalan, M. Batoux, A. Blanchard, J-L. Faulon, F. Kepes, F. Molina, P. Monsan, J. Weissenbach, G. Skretas, E. Stalidzans, R. Jerala, A. Boyce, L. Clarke, P. Frremont, V. Danos, R. Kitney, R. McKibbin, A. Wipat: First Workshop of the European Synthetic Biology Centres, ERASynbio, Imperial College London, July 12th, 2013



Visualization of the PhD and Postdoc projects (UNIK funded and associated) undertaken during the grant period. In the figure, PhD and postdoc with projects and supervision in one, two or more faculties are shown. The figure illustrates the amount of projects undertaken in collaboration fields and thus the number of new scientists harboring collaborative competences as a result of UNIK

Focus on career patterns: Where are they now?

The UNIK grant has contributed to the education of a large group of PhD students that have been equipped with a state-of-the-art portfolio of competences to further their career. A closer study of the career patterns of the UNIK-funded and UNIK-associated PhD students discloses that the environment primarily educates for a continued career in science, either in academia or industry. As can be seen below, 50 % of the PhD students stay within academia and of these almost 1/3 continues in international environments while the rest stay in Denmark. Of the students preferring a career in the private sector, 2/3 continues working within science in the private sector, underlining the involvement and integration of UNIK-acquired tools and competences in industry.



CHAPTER 6: FUNDING ACHIEVEMENTS

Attraction of Funding

Basic core funding from the University of Copenhagen, combined with a strategic focus on future external funding possibilities, industrial collaboration and societal engagement, is essential to achieve a long-term embedment of synthetic biology at University of Copenhagen.

A total amount of **445 mio DKK** has been achieved by the UNIK researchers, disclosing an almost four-doubling of the UNIK grant during 2009-2014. Continuation of the Synthetic Biology endeavor is highly dependent upon external funding (see Embedment page 77)

External funding demographics

The demography of funding types as illustrated in Figure 1 shows a strong emphasis on research programs which includes several research projects highlighting the embedded nature of the enabled ability to attract larger programs with broader aspects and scientific endeavors includedⁱ.

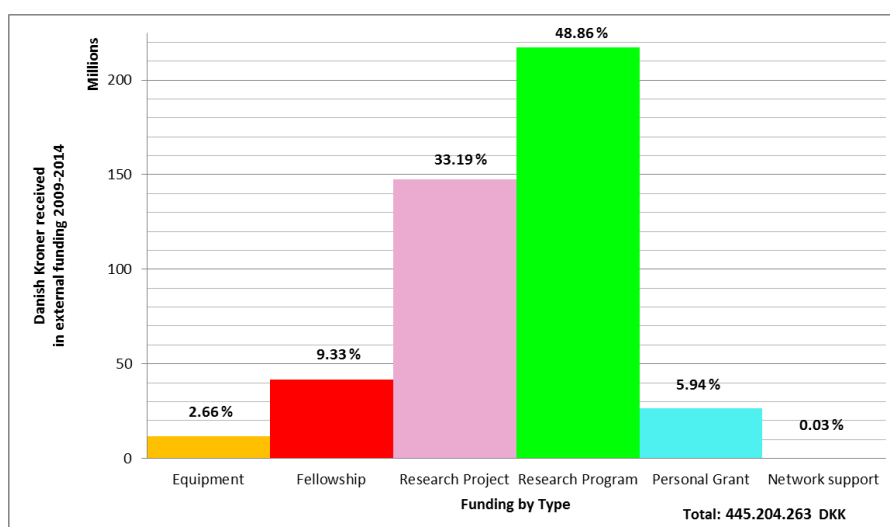


Figure 1

Among the prominent research programs that will continue Synthetic Biology research attained during UNIK are:

- **ERC Advanced Grant** (Birger Lindberg Møller): 18.6 mio DKK
- **Plant Power** (Strategic Research Council, Poul Erik Jensen): 20.7 mio DKK
- **bioSYnergy** (UCPH Excellence Programme for Interdisciplinary Research³, the UNIK group): 26.3 mio DKK
- **VILLUM Research Center for Plant Plasticity** (Birger Lindberg Møller): 24.6 mio DKK
- **CoNeXT on X-ray and Neutron Scattering** (Kell Mortensen): 27.9 mio DKK

Overall demographic of the UNIK community's funding capacity

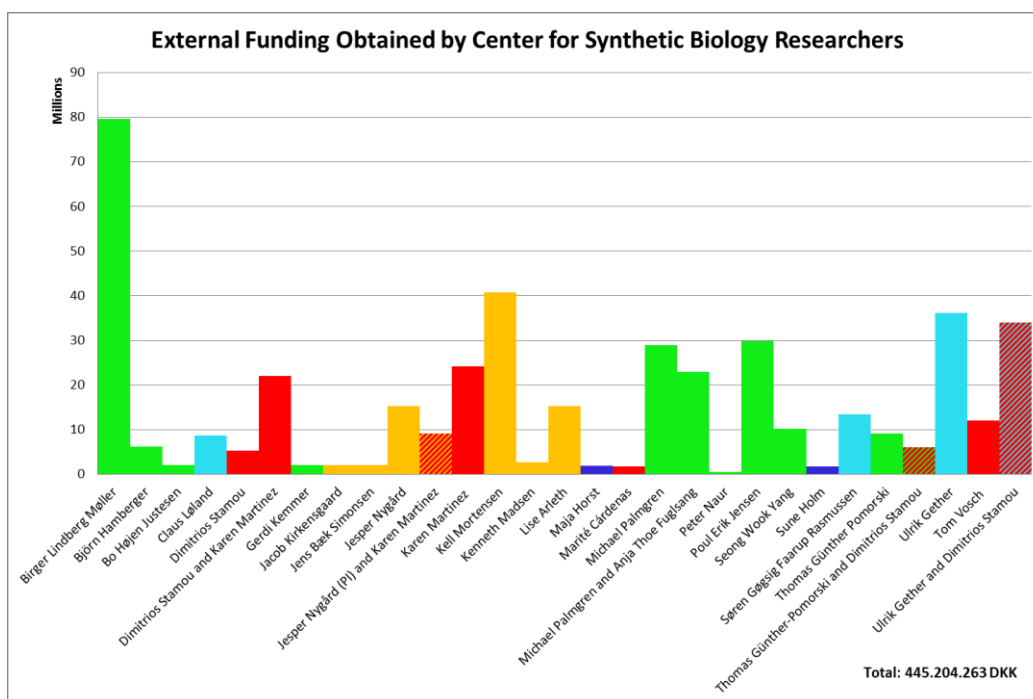


Figure 2: Funding obtained by the individual PIs. For grant programs involving several of the participants only the PI in charge of the program is credited for the grant.

The scientific excellence and competences of the scientists participating in UNIK initiative continues to attract extensive external funding and as such create the foundation for continued efforts within synthetic biology as well as the closely associated areas.

Examination of the funding capacity of the participating scientists show that the PI group of UNIK have performed outstandingly in the grant period and have shown strong ability to attract external funds.

A full list of external grants can be found in the Appendix

³ The bioSYnergy grant has been granted by University of Copenhagen and is as such not strictly an external grant. Application criteria based on competition and international review.

CHAPTER 7: LEADERSHIP AND COMMUNITY

Leadership and Community

The scientific leadership profile of Center for Synthetic Biology has been developed and exercised with a view to ensuring research excellence, further strengthening of our unique research base and to foster a strong cross-disciplinary working environment with focus on inclusion and continued personal engagement of the individual participants in the developing field of Synthetic Biology.

The Center is a virtual center as it comprises several non-co-located faculties across Copenhagen. Establishing a strong collaboration culture has therefore been key to the success of the center. This has been achieved through the leadership structures as well as a set of formal structures and community-aiding initiatives (see below) working in unison in order to attain a strong and sustainable community beyond UNIK.

Academic and engaged leadership

The high complexity of the UNIK synthetic biology research initiative has been guided by academic leadership at all levels rather than by forced simplicity, the latter typically being preferred by managers who have not prevailed in science. This approach of **leadership by example** with an engaged and passionate involvement of the UNIK Steering Group has served to invoke this spirit at all levels.

The leadership consists of an interwoven array of both formal and informal bottom-up and top-down structures, with academic leadership by example as the overall guiding principle. A strong, formal and mutually respectful cross-disciplinary collaboration culture, and encouragement of strategic visibility to further improve attraction of external funding and profiling of the UNIK synthetic biology community among the stakeholders are other important guiding principles. Furthermore, all researchers and support staff are given the opportunity to operate as independently as possible as this constitutes a key motivation factor to perform and take charge. Obviously, these guiding principles need to be delicately balanced against each other to be successful.

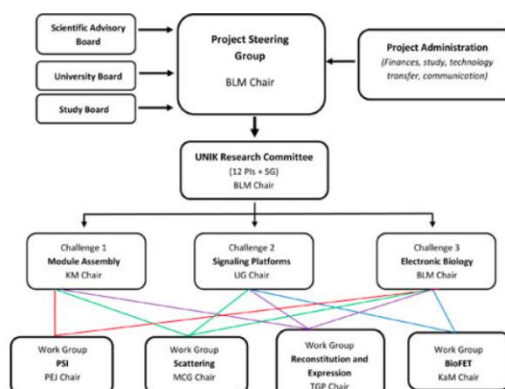
Continued efforts to ensure strategic visibility and to attract external funding (see Synthetic Biology Stakeholder Platform), as well as the measures taken to promote the highly interdisciplinary scientific community which Center for Synthetic Biology represents, are additional important parameters in the leadership profile. This enables continued personal engagement and serves to establish a career-promoting research environment to the benefit of the individual participants.

Formal structures

Infrastructure and collaboration structures have been developed with excellence and interdisciplinarity in focus. In the network structures formed, all participants are exposed to other disciplines as well as encouraged to contribute to projects with their disciplinary expertise. Research based academic leadership has been successfully maintained at all levels.

The formal structures of UNIK-Synthetic Biology includes:

- **Head of Center:** Birger Lindberg Møller
- **UNIK Steering Group:** Ulrik Gether, Kell Mortensen, Birger Lindberg Møller and Bo Wegge Laursen. Monthly meetings covering overall strategies, priorities, instrumentation issues, recruitments, communication, external meetings and economy. ⁴
- **UNIK Research Committee:** The cross-disciplinary committee consisting of the 15 senior scientists as well as the UNIK Steering Group. Bimonthly meetings focusing on progress of projects, challenges, failures and successes are presented and discussed in the committee, which often gives rise to novel input from participants from different core projects.
- **From Health:** Ulrik Gether (Vice Chairman, INF); Claus J. Løland (INF), Søren G. Rasmussen (INF); **From Science:** Birger Lindberg Møller (Chairman, PLEN); Seong W. Yang (PLEN), Björn Hamberger (PLEN), Poul Erik Jensen (PLEN), T. Günther-Pomorski (PLEN), Professor Morten Meldal (KI), Marite C. Gomez (KI), Karen L. Martinez (KI), Dimitrios Stamou (KI), T. Vosch (KI); Kell Mortensen (NBI), Lise Arleth (NBI), Jesper Nygård (NBI); **From Humanities:** Sune Holm, (Media, Cog & Comm).
- **Work Groups:** Four cross-disciplinary work groups (Photosystem I, Reconstitution and Expression, Scattering, BioFET), each headed by a participant of the UNIK Research Committee, have been established with bimonthly as well as ad hoc meetings for detailed discussion of the progress of the specific projects of each work group.



⁴ Professor Robert Feidenhans'l is no longer a member of the UNIK SG. Professor Feidelhans'l resigned when he was appointed Head of the Niels Bohr Institute. A dual position as grant holder in the UNIK as well as a governing and funding function as Head of the Niels Bohr Institute was not judged acceptable. The position as Head of the Niels Bohr Institute became vacant when the previous Head, John Renner Hansen, was appointed Dean of the newly formed Science Faculty. Morten Meldal resigned his position as Head of the Nano-Science Center when he was appointed 'Lighthouse' professor in Evolutionary Chemical Biology at Department of Chemistry in March 2013 with a 35 mio DKK grant. Bo Wegge Laursen was subsequently appointed head of the Nano-Science Center and replaced Morten Meldal in the UNIK SG.

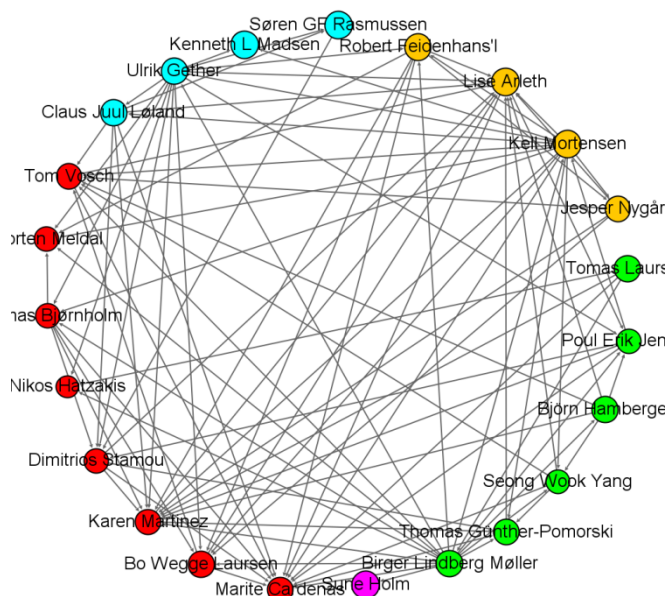
- **The PhD-structure:** Each of the 27 co-funded PhD-projects have been set-up as to encourage strong cross-disciplinary research. Each PhD-study is organized with supervisors from two institutes, albeit with one 'mother'-institute in order to attain a stabile working environment and affiliation.

The formal structures of UNIK continue in the Center for Synthetic Biology after the grant period and have now been adapted to encompass the participants in the bioSYnergy Project. Se more at http://synbio.ku.dk/project_list/biosynergy/

Culture and cross-disciplinary collaboration

The establishment of a research culture based on collaboration among different research groups was at the heart of UNIK-initiative from the beginning and spurred by the UNIK Research Committee members. The collaborations are based on mutual respect and confidence and further supported by concrete measures visualizing the community, e.g. a monthly newsletter (Synbio News), and extensive profiling of the participating researchers as well as their collaborations and results on the center webpage (www.synbio.ku.dk) and in the media. Furthermore, social events and seminars are cornerstones to support the cultural development, the cross-disciplinary inspiration and common idea creation for project developments:

- **Yearly two-day Center meetings** have been undertaken to develop the all-over knowledge and progress of the scientific projects. Furthermore, the meetings serve to further develop the prosperous working environment in creating personal relationships between the participants. The members of the Science Advisory Board are invited and often participate in these meeting, providing their independent view of the center activities as specified in a joint report.
- **The Network of Young Synbio Investigators (NYSI)** has been established for PhDs and Postdoc students at the center to support research collaboration, social engagement and career-development. The informal meetings which take place outside the University (coordinated by the UNIK secretariat), give the network access to people who are stakeholders in science as well as society, e.g. industry representatives, members of funding bodies, entrepreneurs or scientists with particular interdisciplinary and diverse backgrounds, thereby giving the students a strong external network. See: <http://synbio.ku.dk/nysi/>
- **Scientific Seminars** are arranged at the center on a regular basis and whenever possible, visiting or invited collaborators are invited to share their research with the center participants. For events see: <http://synbio.ku.dk/events2/>



Collaborations

The formal and informal structures have enabled a number of collaborations between the PIs that far outnumber the established collaborations in Work Groups and projects enabling the growth of a new network culture with close ties between the scientists that have been exposed to expertise, knowledge, methods and scientific communities different from their native environment. Currently, new collaborations and projects are arising from the established synthetic biology network enabling

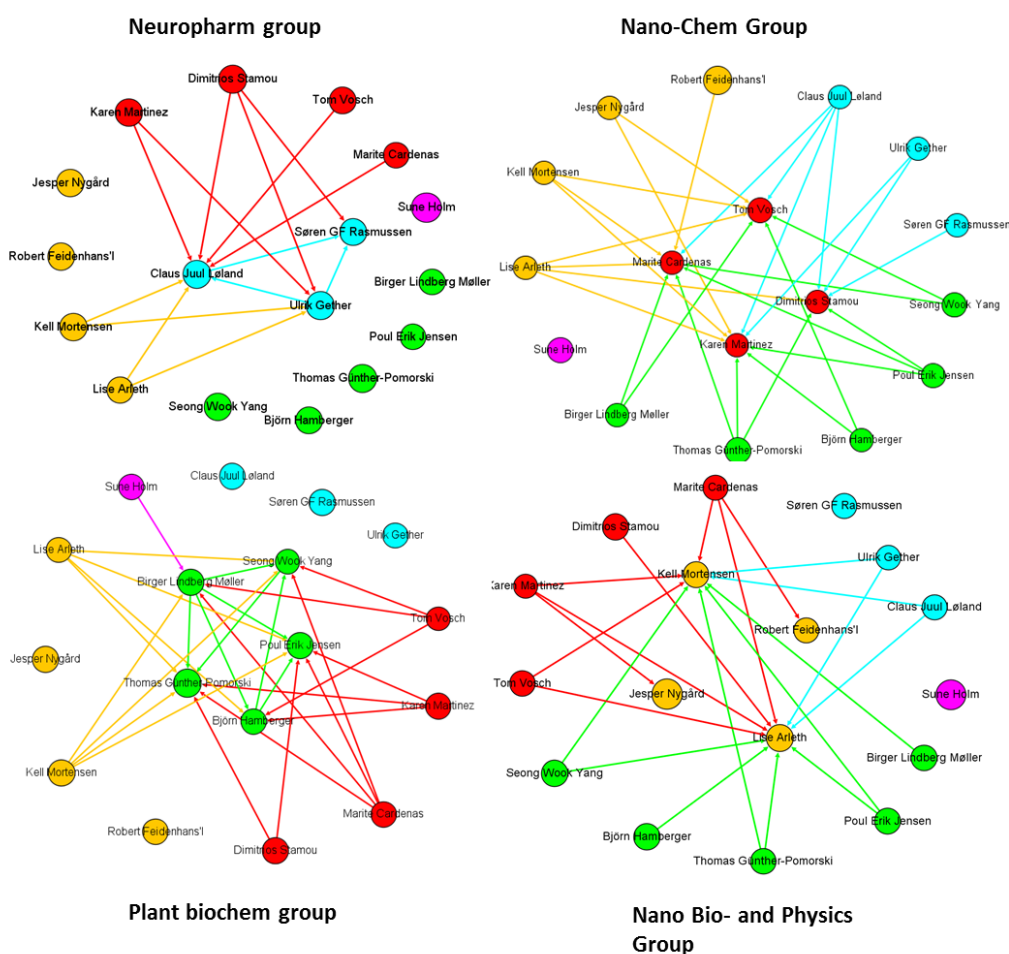
harvesting of results and collaborations both presently and prospectively.

UNIK group of PIs initiative have established a very large number of connections between all the participating faculties and groups as seen in the figure

Strengthening the interdisciplinary profile of UCPH

Access to the extensive knowledge-base in the development and successful management of the UNIK initiative has been a key focus area for the UNIK Center for Synthetic Biology which is often referred to as the role model for the University of Copenhagen in terms of cross-disciplinary and positioning in the European Challenge-based funding landscape.

As such, extensive contributions have been given to e.g. the novel initiative Criss-Crossing University of Copenhagen, which aims at capturing and profiling this type of knowledge across UCPH. The web-based platform envisioned for the results of this initiative will give access to the center's knowledge and tools and furthermore, serve as a fertile resource and inspiration platform for future initiatives internally at UCPH as well as a profiling tool for external use. Contributions are also be given to the initiative 'KU med Kant' ('KU with an edge') which will serve as an external show-case and internal information hub for cross-faculty and – disciplinary focus areas of University of Copenhagen.



Establishing the foundation of a new network culture

A foundational contribution to the establishment of a cross-disciplinary culture of collaboration across the University is the establishment of a large base of cross-disciplinary connections between the majority of the PIs. This will add further to the knowledge base for current and future projects between the participants. Moreover, this strong 'education' of ambassadors of the potentials of cross-disciplinary collaborations will keep spreading virally across the University.

Key learning points in leadership and management

As one of the first cross-disciplinary synthetic biology communities in Europe, several key learning points have been gained during the grant period.

- **Cross-disciplinarity is far more than disciplines collaborating across fields.**

Collaboration between fields and competences is not new to the scientific field and the definition of what the true parameters of collaboration are is still a field of exploration. Currently this is subject to both subjective and strategic interpretations.

However, clear distinction must be made between at least two distinct types of collaboration:

Puzzle-solving Collaboration where each partner participates with significant, but individual pieces to the puzzle.

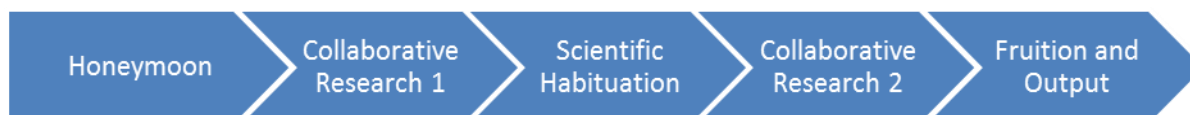
Emergent Collaboration which aims at creating a field that is and can attain more than the sum of the parts. This is also often referred to as transdisciplinary collaboration.

It is in the latter of the two that the true potential of converging science can be found. This is where truly novel discoveries can be made and unseen breakthroughs can result. It is also a highly demanding form of collaboration with a number of challenges in the cultures of scientific fields, the University as an institution, the publication and peer-review cultures of all sciences, current collaboration incentive structures and the current knowledge gap of the parameters that can satisfactorily measure and describe true cross-disciplinary collaboration.

Center for Synthetic Biology aims at attaining an Emergent Collaboration culture and has as such gained tremendous support from the UNIK grant in this endeavor.

- **The Phases of Collaboration**

As with all scientific progress, cross-disciplinary collaboration does not necessarily follow a straight line of progression. However, what distinguishes the fluctuations in cross-disciplinary collaboration is based in structural elements as much as in scientific progress. In UNIK-Synbio five distinct phases have been observed in the progression of the collaboration.



Honeymoon Phase; Ignited by the passionate and visionay outset of UNIK, the participants hearts and minds are passionately engaged in the establishment of collaborations and the scientific set-up.

Collaborative Research 1: Projects have been established, launched and priliminary data is produced. Depending on expectations and the degree of success attained at this level, several scenarios can unfold

and they are key to the unfolding of the subsequent phases. The scenarios generally fall in the following, but non-comprehensive categories:

Blue Skye results entails giant strides forward as in the case of the Light Driven Projects

Successful data and collaboration supports continued and focused project continuation as in the case of e.g. the nanowire and the foundational membrane protein projects

Unexpected, delays or unsuccessful results entail a reevaluation of the project leading to new set-up or termination of the project as was the case of the toxin terminator initially envisioned by the UNIK group.

Scientific differences will also reveal themselves at this point. Apparent differences and challenges in scientific language, such as the use of the same terms for different entities or simply challenges in accessing non-native scientific fields harboring highly different vocabulary and scientific terms.

Scientific Habituation follows Collaborative Research 1. At this point the participants have gained collaborative experience and differences have been disclosed. Depending on the prior experiences in Collaborative Research 1, scientists now enter a habituation phase where adaptation and transference of knowledge between the fields can happen widely, project potentials can be widened and the collaboration can grow more focused and ambitious.

However, in this phase it is highly important to notice differences or challenges that appear scientific and/or competence-based while being rooted in structural or methodological differences. The Plant biochemists and the Biophysics experienced this at this phase in the exchange of samples produced by the plant biochemists to be measured on by the biophysics group. Samples were continually not deemed pure enough by the biophysics while the Plant biochemists produced samples meeting the highest level of purification. While avoiding animosity between the groups, the specific period of time was challenging for the groups in terms of collaboration until it was disclosed that the level of purification was methodologically approached in the two groups. Analysis on whether these difficulties are rooted in science or in more structural aspects are an important focal point at this phase as they can often be understood and overcome by dialogue.

Collaborative Research 2: Continued collaboration and production of data. At this level, the habituation and approximation of fields work in unison as have been the case in all successful scientific elements of UNIK.

Fruition and output: Lastly the harvesting phase where the scientific work fructifies, articles are produced and impact on the international scientific community is attained. This phase is also a highly potent springboard for continued harvesting of the scientific progress as well as next level collaborations.

This generalized process of cross-disciplinary collaboration is not finite. After the first fruition period a new level of collaboration can be reached and with each iteration the scientific habituation grows stronger and shorter thus adding speed to the following projects.

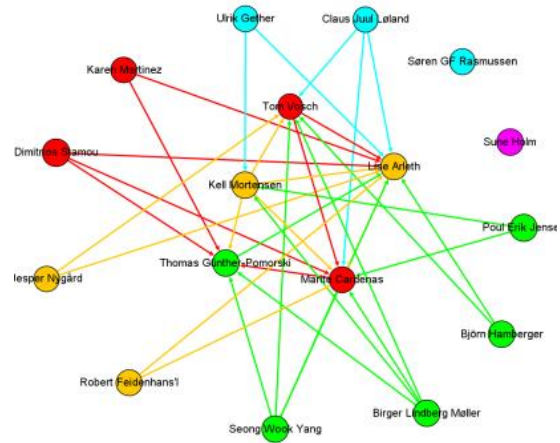
- **Scientific habituation is an individual and strong competence**

The strength of scientific habituation is largely competences gained by the individual scientists in tight-knit dynamic collaboration with other scientists in the specific set-up. The competence is an exceptional tool for further harvesting of the collaboration in continued or new projects. It is competences can be transferred to novel collaboration network with new participants. However,

new participants will themselves need to gain these competences leading to a slow-down or set-back in scientific progress. This is due to the differences between the attained direct and tacit knowledge. Supporting and nurturing the networks that have already attained scientific habituation is therefore highly important for faster scientific knowledge development.

- **Technology platforms are potent collaboration arenas**

Access to shared technology platforms are strong components in the creation of cross-culture collaboration. As experienced in UNIK-Synbio, the platforms supplied by the biophysical group as well as the instrumentation of Tom Vosch have created highly potent collaboration arenas. The advantages for each participant are very clear and the knowledge gained can easily be transferred to other projects thus supporting an expansion of the collaborative potential. This was also very evident in UNIK-Synbio with the participants offering access to such platform being 'hubs' of collaboration. As seen in the figure, these participants have numerous and abundant collaborations throughout the PI group.



- **Academic leadership is paramount**

As outlined on pp 51 leadership of cross-disciplinary collaborations is a highly complex task. Strong, visible, ambitious and generous leadership is crucial. This can only be attained with scientific leadership that can demonstrate broad scientific comprehension, oversee micro-dynamic scientific structures, mentor career patterns in science and manage the strategic level.

Paramount in the leadership is to **nurture a generous culture** by leading as an example. Collaborations will falter without a large degree of trust and sharing of knowledge between the participants. In some scientific communities this approach is by-passed by a competitive and exclusive culture which is lethal to prosperous collaborations.

- **'No minorities' - all are important**

The demographic set-up of cross-disciplinary collaborations such as UNIK-Synbio is not equal in terms of how many scientists from each field participate in the collaboration. The group dynamic is affected by this and any party in minority must be given special attention. Collaboration within the same scientific field such as SCIENCE have an advantage in harboring common ground and understanding in being natives to the same scientific field. Differences are easily overcome between fields. Collaboration between cross-facultary fields does not have the same common ground and is therefore more challenged in collaboration. Difficulties in language and practices as well as understanding and engaging in each other's fields is more time-consuming. As such, historical differences between the factual and the analytical sciences as we find them in e.g. the natural sciences as opposed to the humanities are quite large and must be a focal point of any cross-faculty collaboration.

- **Educating for collaboration**

The tools and understanding of different concepts and approaches to scientific enquiry that the individual researcher brings to a collaboration is largely based on the education and social habituation of their native

field. Bringing gaps in understanding has been a focal point in UNIK-Synbio. However, looking forward, the continued creation of a strong cross-disciplinary collaboration environment at University of Copenhagen would benefit greatly from early collaborative education at the bachelor or master level.

- **Building a new culture is strategic change management and administration**

A number of facets need to be taken into account when cross-collaborating across several scientific fields, each of which has their own culture, practice and structure. These are especially revealed and dealt with in the scientific habituation phase as well as in the strategic elements of a large research program such as UNIK-Synbio.

Ensuring an administration that can create a supporting and progressive framework is a highly important integration tool. Especially fruitful framework tools used in UNIK-Synbio have all been based on constructive habituation processes and creating meaning of all aspects of the initiative, i.e. the new culture, the collaborations, the strategic aims and ambitions within the initiative and in the dialogue with society, politicians and companies.

Furthermore, special focus has been given to creating a fruitful interpersonal relationship between the scientists, both with constructive relationship building exercises as well as a strong digital network with webpage, newsletters and social media (facebook and twitter) all supporting and extending the cross-disciplinary field within UNIK-Synbio.

Skilled and academic administration can also act as ‘sense-makers’ or ‘go-betweens’ between the different scientific groups and create a room for further discussion as well as act as a knowledge hub that can create space for informal discussion of the factual and tacit knowledge needed to be gained by the participants.



- **Communication is vital**

The Synthetic Biology Community is supported by an extensive communication platform focusing on both internal and external communication with a large website, monthly newsletters, social media interaction on facebook and Twitter. These are tools for engagement as many different levels and serve to strengthen the internal identity as well as the collective communication profile externally.

See more:

Web: <http://synbio.ku.dk/>

Facebook: <https://www.facebook.com/synbio.ku.dk>

Twitter: https://twitter.com/bioSYNergy_dk

CHAPTER 8: STRATEGIC ELEMENTS

Strategic elements

The synthetic biology stakeholder palette

To ensure international impact and long-term sustainability of Synthetic Biology at University of Copenhagen Center for Synthetic Biology has developed a strategic approach to all stakeholders involved. The multileveled platform involves six platforms outside the core Center. Each of the platforms have been continuously addressed and developed throughout the grant period.



European funding and collaboration

In order to raise the possibilities of gaining financial support from the EU funding bodies, Center for Synthetic Biology is engaged in short as well as long-term strategic initiatives focusing on the

present framework program (FP7) and the future framework program Horizon2020 as announced in January 2013. The overall aim of these initiatives is to ensure funding possibilities for synthetic biologists within the research areas of the scientists working in the center.

Approaches and accomplishments:

- A successful delegation to Brussels on November 30th 2011 headed by Prorector of University of Copenhagen Thomas Bjørnholm and Provost of DTU Henrik C. Wegener.
- Invitations obtained to give direct input to the Commission on the last of the work programs of FP7.
- With the inputs, we have obtained successful openings in the funding calls in FP7 work program 2013, offering opportunities for the funding and establishment of a cross-European synthetic biology consortium in 2013. Four EU applications have been filed by PIs at the Center for Synthetic Biology.
- The hosting of a visit by Director of Food, Agriculture and Biotechnologies, Maive Rute, to Center for Synthetic Biology and Novo Nordisk Center for Biosustainability on March 28, 2012. The visit was highly beneficial for everyone and the Director asked our help in getting the Bio-economy for Europe higher on the agenda of the Danish ministers.

Synthetic Biology Workshop in Brussels

As a direct result of the delegation to Brussels, we were given the opportunity to arrange a seminar in collaboration with The Science and Technology Options Assessment Unit (STOA) which serves as parliamentary consultant on novel scientific technologies and trends to the Members of the EU parliament.

The focus for the seminar was formulated by Center for Synthetic Biology. The seminar took place on June 6th 2012 in Brussels with the participation of Members of Parliament, Technology Platforms as well as scientific officers of the Commission. The endeavor was done in collaboration the EU-consultants at creoDK⁵.

- The seminar enabled us to directly present our scientific focus areas as well as offered ample opportunities to present the safe-and-sound approaches to the novel techno-science of synthetic biology at Center for Synthetic Biology and Novo Nordisk Foundation Center for Biosustainability. The seminar resulted in subsequent direct contacts to individual MEPs.

Horizon2020

- We have provided inputs regarding the incorporation of synthetic biology in the future framework program Horizon2020 and the current as well as up-coming work programmes. This has been carried out at the EU as well as national level.
- In this regard, the visit from Director of Food, Agriculture and Biotechnologies, Maive Rute, served the purpose of enlarging the Directors knowledge of the volume and international standing of research within synthetic biology in Denmark and contributed to furthering our knowledge of the Commission's visions as to the role of synthetic biology and future possibilities for obtaining EU funding.
- Center for Synthetic Biology has also contributed to the Copenhagen Research Forum report compiling the advice on research priorities from a large group of European Scientists to the European Commission. Synthetic biology is now listed as an important emerging technology in the report.

⁵ CreoDK is the EU-office in Brussels undertaking the interests of both University of Copenhagen, The Technical University of Denmark and the Capital Region of Denmark

ERAsynbio

As of January 2012, an advisory board to the ERAsynbio research network has been working throughout the EU. The Ministry of Research, Innovation and Higher Education has appointed Poul Erik Jensen from Center for Synthetic Biology as the Danish member of the Scientific Advisory Board.

The ERAsynbio network is highly active and thriving. A Strategic Whitepaper which, based on the agreed EASAC and ERAsynbio definitions of the synthetic biology research area, has now been produced. This provides an overview of the strongholds and opportunities of European Synthetic Biology. Poul Erik Jensen, Birger Lindberg Møller and Sune Holm have been appointed as members of the group of researchers to formulate the Strategic White Paper with assistance from the UNIK secretariat.



The Center for Synthetic Biology hosted the ERAnet Science Advisory Board meeting in Copenhagen in November 2013, showcasing the center and its activities within research, ethics and communication.

The Center has also been instrumental in the formation of a background working group at the Danish Ministry of Science and Innovation level with participation of all Danish universities in order to enlarge the Danish impact on the ERAsynbio network and to form the basis for a Danish National Research Program within synthetic biology.

Participation in other European Actions

Poul Erik Jensen is also participating in two COST-actions and Scientific Director Birger Lindberg Møller has been appointed as the Danish member of the European Academies of Science Advisory Council (EASAC). The EASAC members have written and published influential reports on Plant Genetic Resources, Challenges of Climate Change, Concentration Solar Power, Engineered Nano Materials as well as on Synthetic Biology. Furthermore, a report on Genetic Engineering aspects is preparation. The reports have been presented at meetings in Brussels with the MEPs.

Birger Lindberg Møller was appointed member of the evaluation committee reviewing the large scale funding of Synthetic Biology in the United Kingdom. As the outcome of the strategic process to identify the key areas which have potential to provide UK with growth and new job opportunities, Synthetic Biology was selected in 2012. Based on the produced Synthetic Biology Roadmap, a process based on large-scale funding is now being carried out in the UK with the set-up of several large synthetic biology centers across UK. Birger Lindberg Møller takes active part in reviewing and evaluating these centers.

National network and funding possibilities

When advertised, the UNIK program did not allow submission of applications involving researchers from different universities. However, to further develop synthetic biology, it is essential that the

major research groups within the Danish synthetic biology community collaborate to exploit complementary research skills and technology platforms. Accordingly, the establishment of strong national collaboration across the relevant universities continues to be a focus area for the center. Based on invitations from the Center for Synthetic Biology, researchers from Center for Synthetic Biology have met with researchers from Aarhus University, the University of Southern Denmark and the Technical University of Denmark to coordinate our efforts to get synthetic biology on the national agenda in research councils and other possible funding agencies. Stronger national research collaborations are required to make this approach a success. Unfortunately these efforts have not yet been successful with respect to obtaining a joint grant enabling the syn bio environments at KU, Aarhus and Odense to jointly profit from increased collaboration.

Global research network

It is important to maintain and strengthen our interaction with the international research network within synthetic biology to be inspired and obtain guidance and to engage in identifying and addressing the research topics that offer the highest potential for the generation of new important fundamental knowledge. The following efforts have been undertaken in order to maximize our impact:

- The well-established scientific collaboration with University of California at Berkeley including the Joint BioEnergy Institute continues. In August 2011, a three-day, jointly organized overbooked Synthetic Biology conference took place at the Citris Institute at UC Berkeley with more than 120 participants.
- Based on the strategic wish of including the central global synthetic biology hops in this collaboration, a Cold Spring Harbor Asia Symposium on Synthetic Biology was organized in Shanghai in November 2012 as an expansion of the previously joint meetings with the Berkeley researchers. Unfortunately our application to the Ministry of Research, Innovation and Higher Education to cover part of the costs related to organizing this synthetic biology meeting in Shanghai was not funded. As a result, we had to fund part of the costs from the UNIK grant. Birger Lindberg Møller was one of the three members of the organizing committee of the Cold Spring Harbor Asia Symposium.
- Center for Synthetic Biology has also entered into collaboration with the Ministry's Innovation Center in Shanghai to identify elite Chinese researchers within synthetic biology.
- Extensive collaboration efforts with frontier European synthetic biology scientists, particularly from Germany, Switzerland and the UK, have been established and facilitated the filing of four joint EU applications in February 2013.
- The British Government has decided to invest heavily in synthetic biology. 6 new major centers with focus on synthetic biology will be established, each with substantial governmental core funding. Birger Lindberg Møller is one of the two foreign members of the assessment committee currently evaluating which centers should be granted. This gives the Center for Synthetic Biology a unique upfront knowledge of the research activities on synthetic biology in the UK and opens the door for intensified future collaborations.
- Researchers at the Center for Synthetic Biology headed by Ulrik Gether and Dimitrios Stamou organized a Lundbeck Symposium on membrane receptors in March 2013 with key researchers from all over the world participating.
- A conference on Plant Synthetic



Biology is being organized for November 2014 at UC Berkeley in a collaboration between the Plant Power Project and Center for Synthetic Biology. This conference will bring together the competing fields of Synthetic Biology and Organic Synthesis in order to explore knowledge transfer between the fields as well as collaboration for faster market implementation. Key notes are the world leading scientists in their fields, including Jay Keasling and Phil Baran.

Research, innovation and business collaborations

To secure the advancement of the application of synthetic biology in the industrial sector, the researchers at the center are involved in dynamic collaborations with several SME and major industries, as well as actively participating in innovation communities.

High-profile industrial collaboration in this area includes Chr. Hansen, Evolva and Novartis.

Furthermore, Center for Synthetic Biology:

- Has participated in the INNO+ process. The Danish Government has launched an innovation strategy with the goal of creating more jobs in Denmark. In this context, the Government asked the Danish Universities to provide suggestions on how this might be achieved based on unique research competences of industrial relevance. The Center for Synthetic Biology provided a proposal which together with eleven other proposals was given top priority by the University of Copenhagen. The INNO+ proposals have now been evaluated and a road-map of the unfolding of the key areas has been produced. Synthetic Biology is part of this in the Strategic Growth Technology Sections. Launch of this area is yet to be announced.
- Actively engages industrial participants in all strategic endeavors, such as presentations at EU-level (e.g. Evolva and Novozymes).
- Actively participates in innovation forums and platforms (e.g. Nano-Connect, Bio-People, Rebuilt21/Mindshift)

Science and society – and novel trends

The societal and ethical implications of synthetic biology need to be addressed continuously. In our approach to synthetic biology, the aim is to use the principles of nature to construct devices, cells and organisms that fulfill the needs of society is the goal. Creating artificial life is not within this scope. This message needs to be made fully understood to render synthetic biology accepted by the community and politicians. Along the same lines, all production systems for valuable chemicals that we are developing are contained, e.g. algae cultures grown in plastic bags placed in green-houses.

Our efforts in this area include:

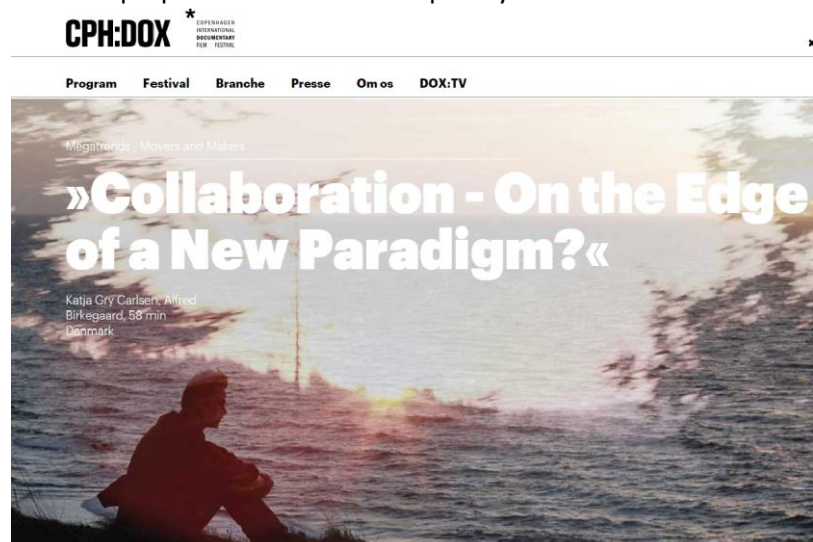
Public and internal dialogue and integration of the ethical dimensions of synthetic biology

- Collaboration with the Ethical Council and the Technical Advisory Board.
- Philosopher Sune Holm's research on potential ethical dilemmas related to the research projects in the center is presented at the internal workshops of the center and in public lectures, as well as in research papers.
- A novel initiative to integrate the ethical dimensions of synthetic biology even closer with the practicing scientists – Ethics Discussion Groups – has now been initiated at the Center. Senior as well as junior scientists participate in these groups based on reciprocal exchange.
- Interaction with organizational ethnologist Cecilie Glerup, whose PhD-project focuses on scientist identity when working within a research area where societal responsibility is integrated. Cecilie Glerup carried out her field work at the Center for Synthetic Biology.

- Extensive participation in the Euroscience Open Forum Conference in June 2014 with several events:
 - Scientific Session: “the Anatomy of Synthetic Biology” focused on the intricate but rarely visible structures of collaborative dialogue between science, industry and the public.
 - Responsible Research and Innovation Installation in collaboration with Maja Horst and the BioSYNergy project.
 - Science Moves Events with a movement and participatory learning forum illustrating production of high value compounds by synthetic biology.
 - Participation in the KopenLab biohacker festival, especially focusing on discussions of ethics, code of conduct, IPR and open innovation.

Integration of novel Research & Innovation trends

- Integration of global trends such as ‘amateur scientists’ of the Do-It-Yourself biotech (DIYbio) community within synthetic biology, to keep momentum. This is not only an effort in terms of securing the ‘right minds’ in this community, but also a great source of inspiration as the open science/open source approach to knowledge development within and outside the established scientific community has the potential of contributing with truly novel approaches to research and innovation. Furthermore, the 26.3 mio DKK grant from the UCPH Excellence Program for Interdisciplinary Research has enabled the inclusion of Law Faculty researchers and HUM Faculty researchers in the synthetic biology research initiative. This widens the scope further with regards to interdisciplinarity in close relation to the fast developing societal trends.
- Co-hosting the exhibition “Biohacking – Do It Yourself” with and at the Medical Museion (part of the Faculty of Health at UCPH) as part of the EU-funded project ‘StudioLab’. The exhibition features an interactive biohacker laboratory, a series of workshops and a seminar (‘Doing and Debating Synthetic Biology’) with participation of Birger Lindberg Møller and Sune Holm, as well as biohackers Martin Malthe Borch and social scientist Sara Davies. (see http://synbio.ku.dk/news/synbio_museion/)
- Participation in a website-based dialogue-forum established by Allan Alfred Birkegaard Hansted, who is a post doctoral fellow financed by Novozymes. The purpose of this cross-disciplinary network is to contribute to new experimental and innovative forms of learning and knowledge creation, especially focusing on the use of social media and collaborative knowledge development (<http://networksociety.org/about/>).
- Participation in Documentary on cross-disciplinary collaboration. Allan Alfred Birkegaard Hansted and Katja Carlsen have on the basis on the above mentioned PhD produced a documentary movie called “Collaboration – On the Edge of a New Paradigm?” with participation of Birger Lindberg Møller. The movie has been selected among several hundreds to premiere at the prestigious Danish film festival CPH:DOX on 7. November 2014. Internationally, as part of our Synthetic Biology Conference at UC Berkeley, the film will premiere on November 11th 2014. See more: <http://collaborativesociety.org/>
- Participation in workshop arranged by the Danish Film Institute in order to bring prominent Danish documentary film makers together with scientists.
- As an outcome of the workshop, Center for Synthetic Biology is now engaged with documentarist Phie Ambo on a common synthetic biology documentary project. Phie Ambo recently premiered the movie “Så meget godt i vente” (So much good to expect) which received the highest reviews.



- Furthermore, the Center intends to engage in collaboration with documentarist Eskild Hart of Ace and Ace Productions. Eskil has distinguished himself by being the only dansih documentarist to produce for Discovery Channel. Most recently he produced “The Man who Doesn’t Breathe” for Discovery:

<http://www.discovery.dk/programmer/the-man-who-doesnt-breathe/>

- Most recently, Center for Synthetic Biology has engaged in collaboration with the prominent italian artist Michelangelo Pistoletto with an installation of the infinity symbol at The Danish Academy of Art with a following debate carried out by junior scientists of Center for Synthetic Biology Tomas Laursen and Johan Andersen-Ranberg.



Media coverage

- Extensive dissemination of scientific results, research and innovation approaches to Danish and international media, as well as social media (see appendix). In this regard, Birger Lindberg Møller was invited to give a talk at the TEDxCopenhagen event in September 2012 (see http://synbio.ku.dk/news/tedxcph2012_talks/).



Capture

In the UNIK Synthetic Biology grant period, Center for Synthetic Biology has achieved:

- **A highly successful research profile within several projects with high-impact potential for future development (see publication list)**
- **The establishment of a research culture based on mutual respect, confidence and willingness to collaborate based on professional academic leadership at all levels**
- **The establishment of infrastructure and facilities to further support and develop our research efforts**
- **The establishment of educational courses within synthetic biology to train and attract young excellent BSc, MSc and PhD students to the center**
- **The establishment of a strong cross-disciplinary collaboration platform**
- **The development of a strategic stakeholder approach to secure future funding possibilities, industrial collaboration and societal engagement:**
 - **Extensive collaboration with national and global synthetic biology community**
 - **Extensive strategic work at the EU-level with successful opening of EU-programs and impact on EU-funding possibilities**
 - **Industrial collaborations and focus on the research and innovation aspects of synthetic biology within both large industry and SME**
 - **Engagement in public dialogue and the citizen science community with novel possibilities of research and innovation**
 - **Focus on ethical aspects of our approach to synthetic biology both within and outside the research community**

CHAPTER 9: EMBEDMENT

Continuation of Synthetic Biology at University of Copenhagen

Contributions from UCPH in ensuring embedment of UNIK Synthetic Biology

The establishment of synthetic biology as a strategic, dynamic and highly promising and pioneering cross-disciplinary research field at University of Copenhagen has offered great benefits to the University of Copenhagen as documented above.

The University of Copenhagen has contributed to this development in the following areas:

Synthetic biology as a strategic focus area

UNIK Synthetic Biology has been included among the University's strategic focus areas and strategic support from University of Copenhagen has been demonstrated in the participation in the delegation to Brussels on November 30th 2011 as well as in development of the research and innovation platform in collaboration with Dansk Industri (Danish Industry).

The Center has also been heard in the process of the development of the university strategy 2016 and the University's input to the Forsk2020 program of the Ministry of Science, Innovation and Higher Education.

The Dean for Science and the Vice Dean for Industrial Collaboration at the University of Copenhagen participated in the visit by EU Director of BioEconomy Maive Rute at Center for Synthetic Biology and Novo Nordisk Center for Biosustainability on March 28th 2012.

Embedment of education

A Master course in theoretical and experimental Synthetic Biology has been established at KU-Science (former KU-LIFE).

A Coursera online course in synthetic biology will be established and premiered in 2015 with the aid of University of Copenhagen. All central senior PIs of UNIK will provide input.

Achievements in embedment of scientific employees

- The center has promoted two Associate Professors to five year PMSO (Professor with Special Obligations) positions financed by the UNIK grant. **The University of Copenhagen funds the salary increases involved when the UNIK grant finishes** (Lise Arleth as of April 1, 2011 and Jesper Nygaard as of December 1, 2011)
- As part of the original application, the University of Copenhagen agreed that three tenure/tenure-track positions for young independent researchers could be announced and funded by the UNIK grant and that the **University of Copenhagen would pay the salary costs involved when the UNIK grant finishes**
 - o **Tom Vosch at KU-Science**
 - o **Seong Wook Yang at KU-Science (former KU-LIFE)**
 - o **Søren Rasmussen at KU-HEALTH**
- In addition, Björn Hamberger was recruited as an independent scientist at the center. His salary is partly paid by the UNIK grant. Financial responsibilities regarding assistant professor Marité Cárdenas Gomez have been embedded in the **Department of Chemistry**.

Embedment of Core Facilities

The three synthetic biology laboratories will continue to be available to the scientists currently recruited in Center for Synthetic Biology after the end of the UNIK grant under the prerequisite that sufficient funding is available to maintain the employment of core staff and a critical mass of post docs, PhD students and MSc and BSc students, and given that the maintainance of the facilities can be funded by the University of Copenhagen.

As mentioned earlier, The University of Copenhagen is engaged in major investments in new buildings: The Nano Science Center will profit from the establishment of the **Niels Bohr Science Park** at the North Campus. The Neurobiology Group will benefit from the establishment of the **Panum Tower** in which advanced costly equipment and technology platforms are planned to be installed. At the Frederiksberg Campus, the University of Copenhagen is investing in the building of the **Copenhagen Plant Science Center**. This new facility is stipulated to house the research activities within synthetic biology. In combination with these new facilities and augmented by the establishment of the **ESS facility in Lund**, University of Copenhagen will stand out and be able to improve its overall international ranking.

The Center for Synthetic Biology is determined and able to be an important contributor to these efforts provided the center's activities are properly embedded and supported by core funds from the University of Copenhagen in the next four year period as outlined below.

Embedment of UNIK center approaches to science management

The UNIK Center for Synthetic Biology at the University of Copenhagen is often referred to as a role model operating in an efficient and well managed manner. Desires to expand this type of center activities throughout the University of Copenhagen are expressed and participation in such center activities is anticipated to optimize the possibilities to obtain funding from the EU Horizon 2020 funding scheme.

Center for Synthetic Biology furthermore stands as a role model for the University of Copenhagen in terms of its cross-disciplinary collaboration and from giving high priority to basic science research initiatives that fulfill the criteria of being innovative and challenging, as well as offering a high potential spin off to society and industry with respect to addressing grand societal challenges.

In this regard, the university leadership is contemplating to drawing new experiences and profiting from the knowledge-base generated at Center for Synthetic Biology, as well as from related centers at the University of Copenhagen both at the scientific, managerial and administrative levels. The Center is actively engaged in the dialogue process and seminars established by University of Copenhagen to aide the progress of the projects funded by the UCPH Excellence Program for Interdisciplinary Projects.

APPENDICES

Appendix A: External funding obtained by the UNIK PIs

Total: Approximately 445.204.263 (Four hundred and forty five million, two hundred and four thousand, two hundred and sixty three) Danish Kroner

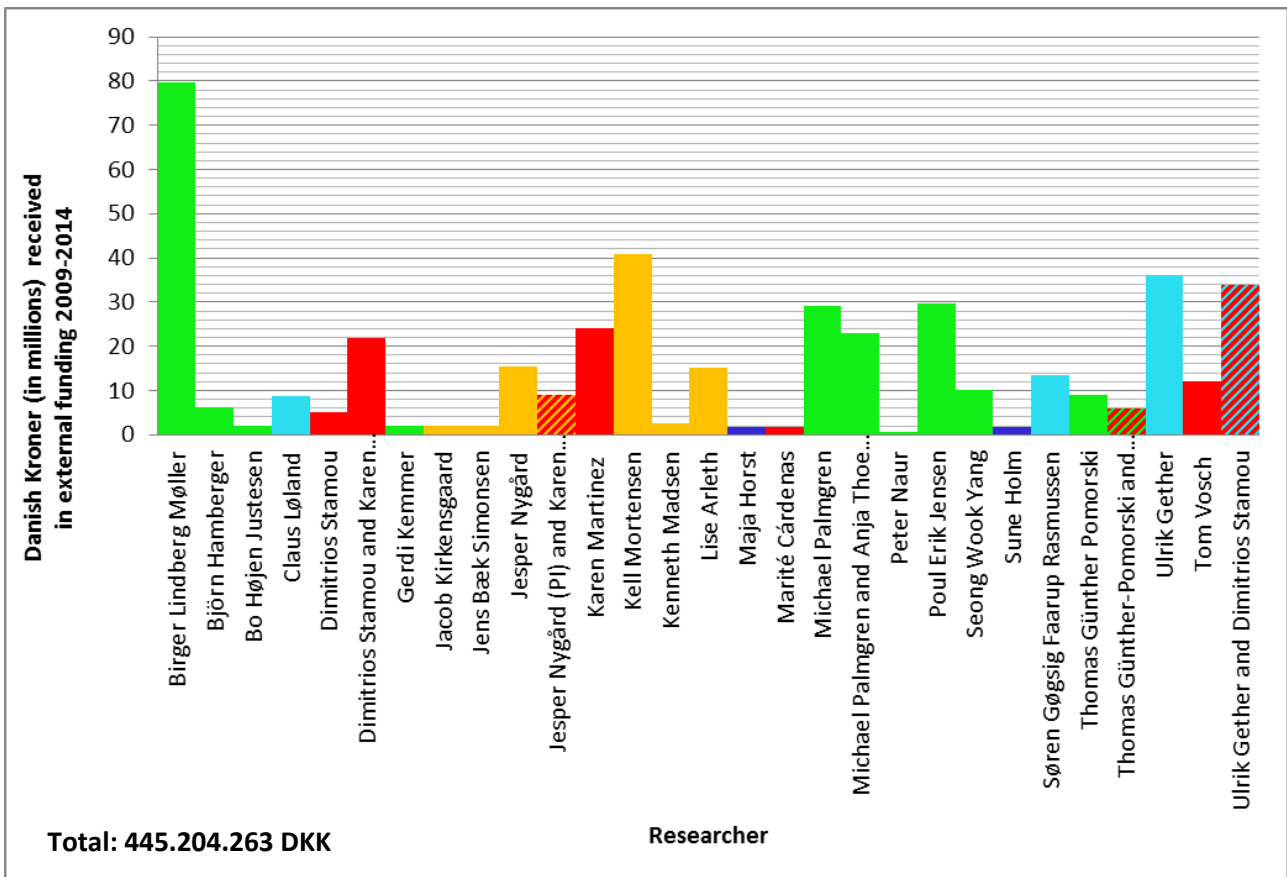
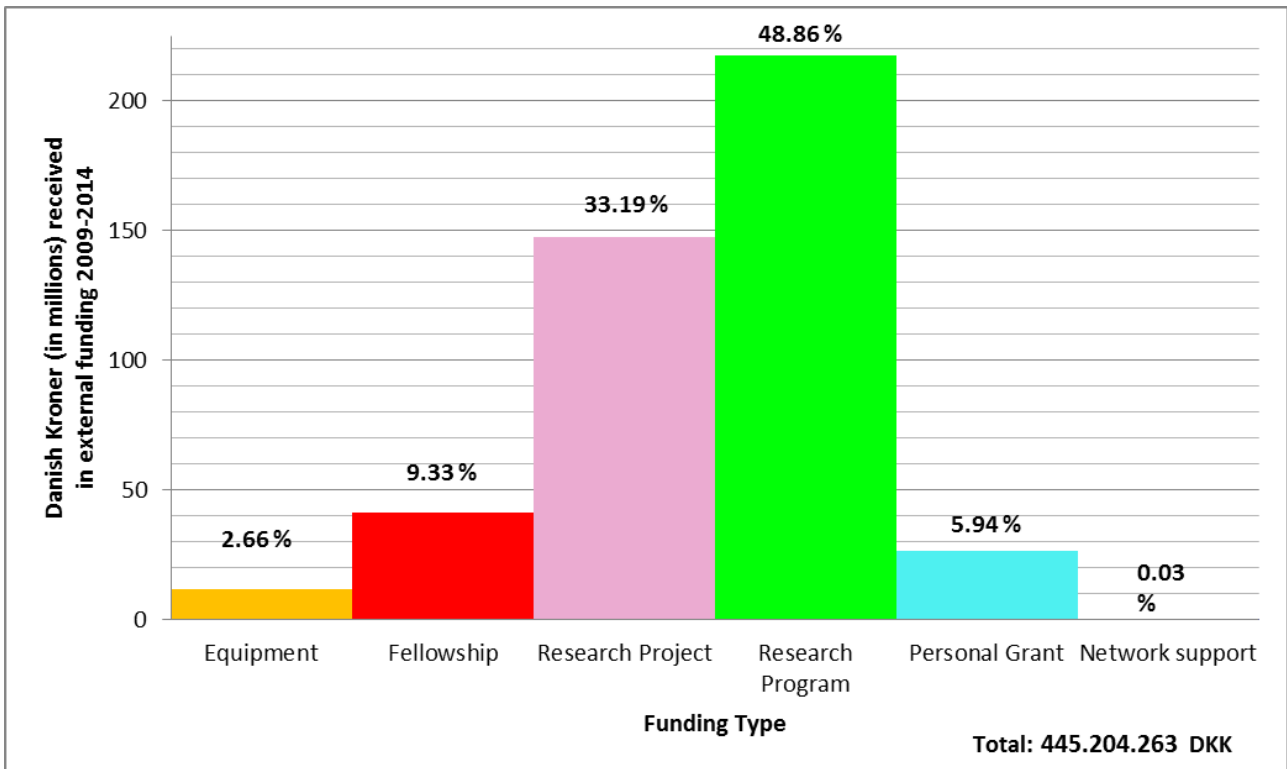
Researcher	Funding Body	Reason	Amount	Researcher Affiliation	Type
Anja Thoe Fuglsang	JA Phd Forening	Travel grant	10.000 DKK	UNIK	Personal grant
Birger Lindberg Møller	Villum Fonden	Pro-Active Plants research centre: Full grant: 3.3 million Euro / 24.6 million Danish Kroner	3.6 mio. DKK	UNIK	Research program
Birger Lindberg Møller	Novo Nordisk Foundation	Novo Nordisk Foundation Center for Biosustainability. Full grant: 85 million Euro / 631.7 million Danish Kroner	25 mio. DKK	UNIK	Research program
Birger Lindberg Møller	European Union	Marie Curie Training Network Full grant 4.1 million Euro / 30.5 million Danish Kroner	4.5 mio. DKK	UNIK	Research project
Birger Lindberg Møller	European Research Council	ERC Advanced Researcher Grant	18.6 mio. DKK	UNIK	Research program
Birger Lindberg Møller	Villum Fonden	Villum Foundation Post Doc Block Stipend	1.5 mio. DKK	UNIK	Fellowship
Birger Lindberg Møller	University of Copenhagen	UCPH Excellence Programme for Interdisciplinary Research (2016 Funds)	26.3 mio DKK	UNIK	Research program
Björn Hamberger	Novo Nordisk Foundation	Plants for the future	2.8 mio DKK	UNIK	Research project
Björn Hamberger	EU, Marie Curie	Postdoc Fellowship Irini Pateraki	1.5 mio DKK	UNIK	Fellowship
Björn Hamberger	DAAD	Summer student fellowships	25.000 DKK	UNIK	Fellowship
Björn Hamberger	EU COST Action Toyota Foundation OTICON Fonden	Several travel grants Johan Andersen-Ranberg	30.000 DKK	UNIK	Personal grant
Björn Hamberger	JSPS	Exchange program with Prof. Koki Fujita	150.000 DKK	UNIK	Network support
Björn Hamberger	JSPS/Universities Denmark	Exchange program with Prof. Toshiyuki Ohnishi	100.000 DKK	UNIK	Network support
Björn Hamberger	EU	PlantPower; coordinator Poul Erik Jensen (full grant 20 mio DKK)	1.5 mio DKK	UNIK	Research program
Bo Højen Justesen	University of Copenhagen	Free PhD Stipend	1.98 mio. DKK	UNIK	Fellowship
Claus Løland	Danish Council for Independent Research	Sapere Aude Grant	6.4 mio. DKK	UNIK	Personal grant
Claus Løland	Lundbeckfoundation		2 mio. DKK	UNIK	Personal grant
Claus Løland	Carlsbergfoundation		200,000 DKK	UNIK	Personal grant
Dimitrios Stamou	Lundbeck Foundation		1.2 mio. DKK	UNIK	Personal grant

Researcher	Funding Body	Reason	Amount	Researcher Affiliation	Type
Dimitrios Stamou	Lundbeck Foundation	PhD stipend	1.2 million DKK	UNIK	Fellowship
Dimitrios Stamou	Høj Teknologi Fonden	Industrial Separation and Biosensing Processes inspired by Nature	Total 89 mio. DKK, personal share: 2 mio. DKK.	UNIK	Equipment
Gerdi Kemmer	University of Copenhagen	Free PhD Stipend	1.98 mio. DKK	UNIK	Fellowship
Jacob Kirkensgaard	Lundbeck	Post Doc hos Kell Mortensen	2.0 mio. DKK	UNIK	Fellowship
Jens Bæk Simonsen	Lundbeck	Post Doc hos Kell Mortensen	2.0 mio. DKK	UNIK	Fellowship
Jesper Nygård	EU FP7 STREP, SE2ND	Nanowire materials and devices	2,434,600 Danish Kroner	UNIK	Research project
Jesper Nygård	Forsknings- og Innovationsstyrelsen	ANaCell	5,658,000 Danish Kroner	UNIK	Research project
Jesper Nygård	Højteknologifonden	Nanowire solar cells	2,908,800 Danish Kroner	UNIK	Research project
Jesper Nygård	FNU	Instruments	1,818,134 Danish Kroner	UNIK	Equipment
Jesper Nygård	Carlsbergfondet	Instruments	2,500,000 Danish Kroner	UNIK	Equipment
Jesper Nygård (PI) and Karen Martinez	Forsknings- og Innovationsstyrelsen Strategic fund	CLIPS	9 million Danish Kroner	UNIK	Research project
Karen Martinez	Forsknings- og Innovationsstyrelsen Strategic fund	ANaCell	12.5 mio. DKK	UNIK	Research project
Karen Martinez	Danish Council for Technology and Innovation	DIMP	2.1 mio. DKK	UNIK	Research project
Karen Martinez	Lundbeckfonden	Center of Excellence in Biomembranes in Nanomedicine	3 mio. DKK	UNIK	Research program
Karen Martinez	Lundbeckfonden	GPCR on surfaces	1 mio DKK	UNIK	Research project
Karen Martinez	French Embassy		18,000 Danish Kroner	UNIK	Personal grant
Karen Martinez & Eduardo Della Pia	Research Council - FTP	Diagnostics with Nanowire arrays	3 mio. DKK	UNIK	Research project
Karen Martinez & Sara Bonde	Research Council - FTP	Nanowires in cells	2.5 mio. DKK	UNIK	Research project
Kell Mortensen	Danish Council for Independent Research	Together with DTU	5.8 mio. DKK	UNIK	Research project
Kell Mortensen	Carlsberg	Instrument funding	0.8 mio. DKK	UNIK	Equipment
Lisa Theorin	BioBricks Foundation SB5.0	Young Researcher Travel Award	\$750/4500 DKK	UNIK	
Lisa Theorin	Journal of Cell Science	Travelling Fellowship	20,000 DKK	UNIK	

Researcher	Funding Body	Reason	Amount	Researcher Affiliation	Type
			24.000		
Lise Arleth	Danish Council for Independent Research	Sapera Aude Grant	8.6 mio. DKK	UNIK	Personal grant
Lise Arleth	European Spallation Source	1/3 PhD grant	0.6 mio. DKK	UNIK	Fellowship
Lise Arleth	Lundbeck Foundation	Post Doc funding for Rasmus Høiberg Nielsen	1.3 mio. DKK	UNIK	Fellowship
Maja Horst	Tips og Lottomidler from the Ministry of Science	Installation om Forskningens Sociale Ansvar (Installation about Scientific Social Responsibility)	175.000 DKK	BioSynergy	Research project
Maja Horst and Sarah R Davies	Marie Curie IIF	Materiality and Affect in Public Engagement with Science (MAPES)	1.637.703 DKK	BioSynergy	Research project
Marité Cárdenas	European Spallation Source	PhD grant	1.3 million DKK	UNIK	Fellowship
Marité Cárdenas	Unesco-L'Oreal Prize Denmark	Women in Science	100.000 DKK	UNIK	Personal grant
Marité Cárdenas	Various minor grants		350.000 DKK	UNIK	Personal grant
Michael Palmgren	Danish National Research Foundation	Center for Membrane Pumps in Cells and Disease	15 mio. DKK	UNIK	Research program
Michael Palmgren	Danish Council for Strategic Research	FungalFight	14 mio. DK	UNIK	Research project
Michael Palmgren, Anja Thoe Fuglsang	University of Copenhagen	UCPH Excellence Programme for Interdisciplinary Research (2016 funds): Plants for a changing world	23 mio. DKK	UNIK	Research program
Peter Naur	Carlsberg Foundation	Salary and expenses	563.164 DKK	UNIK	Personal grant
Poul Erik Jensen	Bonus PhD	Thiyagarajan Gnanasekaran	1,5 mio DKK	UNIK	Fellowship
Poul Erik Jensen	EU	ITN: "Photo.comm" (full grant: 20 mio DKK)	2.4 mio. DKK	UNIK	Research project
Poul Erik Jensen	High Tech Foundation	Project: Biomass for the 21. Century (full grant 112 mio DKK)	2.2 mio. DKK	UNIK	Research project
Poul Erik Jensen	Danish Council for Strategic Research	Plant Power: Light-driven synthesis of complex terpenoids using cytochrome P450s	20.7 mio. DKK	UNIK	Research program
Poul Erik Jensen	Novo Nordisk Foundation	Sustainable production of forskolin	2.4 mio. DKK	UNIK	Research project
Poul Erik Jensen	Research and Innovation Foundation	SynBio conference in Berkeley Nov. 2014	0.288 mio. DKK	UNIK	Network support
Poul Erik Jensen	Research and Innovation Foundation	International Network: Improving plants for food, fuel and bioactive natural products. 2010	0.313 mio. DKK	UNIK	Network support

Researcher	Funding Body	Reason	Amount	Researcher Affiliation	Type
Seong Wook Yang	SeouLin Bioscience Ltd. Collaboration	Project: miRNA detection method	3 mio. DKK	UNIK	Research project
Seong Wook Yang	KAERI collaboration	Project: Bio-remediation	0.8 mio DKK	UNIK	Research project
Seong Wook Yang	DSF, FTP grant	Project: Bio-bunker production Coordinator: Henrik Toft Simonsen	6.4 mio DKK	UNIK	Research project
Sune Holm	Research Council for Culture and Communication (FKK)	2-year postdoc	1.798.610 DKK	UNIK	Fellowship
Søren Gøgsig Faarup Rasmussen	Lundbeck Foundation	Junior Group Fellowship	10 mio. DKK	UNIK	Fellowship
Søren Gøgsig Faarup Rasmussen	FSS	Project funding and postdoctoral fellowship for Xavier Kubiak	3 mio. DKK	UNIK	Fellowship
Søren Gøgsig Faarup Rasmussen	Carlsberg Foundation	Project funding and equipment	300.000 DKK	UNIK	Research project
Søren Gøgsig Faarup Rasmussen	A.P. Møller Foundation for the Advancement of Medical Science	Equipment grant	90.000 DKK	UNIK	Equipment
Thomas Günther-Pomorski and Dimitrios Stamou	FNU	Research grant	5.990.400 kr	UNIK	Research project
Thomas Günther-Pomorski	Villum Fonden	Research grant	5.018.390 kr	UNIK	Research project
Thomas Günther-Pomorski	Lundbeck Fonden	Research grant	1.968.400 DKK	UNIK	Research project
Thomas Günther-Pomorski	Carlsberg Fonden	Equipment (Free Flow Electrophoresis)	250.000 DKK	UNIK	Equipment
Thomas Günther-Pomorski	Augustinus Fonden	Equipment (Free Flow Electrophoresis)	165.000 DKK	UNIK	Equipment
Thomas Günther-Pomorski	FNU	Research grant	1.631.023 DKK	UNIK	Research project
Tom Vosch	SDC	PhD grant	1.5 mio.DKK	UNIK	Fellowship
Tom Vosch	Villum Fonden	Young Investor Programme	6 mio. DKK	UNIK	Personal grant
Tom Vosch	DFE (Danish Research Foundation)	Nanogap luminescence as a new tool for studying molecular electronics and fluorescence enhancement	2.3 mio. DKK	UNIK	Equipment
Tom Vosch (co applicant)	Carlsberfondet	Instrumentation for studies and development of novel fluorescent sensors and	250.000 DKK (personal share)	UNIK	Equipment

Researcher	Funding Body	Reason	Amount	Researcher Affiliation	Type
		labels.			
Tom Vosch (co applicant)	HFSP	young investigator grant	2.016.065 DKK (personal share)	UNIK	Personal grant
Ulrik Gether	Novo Nordisk Foundation	Research grant	900.000 DKK	UNIK	Research project
Ulrik Gether	FSS (Danish Medical Research Council)	Postdoctoral Fellowship Kenneth Madsen 2010	1.5 mio. DKK	UNIK	Fellowship
Ulrik Gether	Lundbeck Foundation	Postdoctoral Fellowship Mattias Rickhag 2011	1.5 mio. DKK	UNIK	Fellowship
Ulrik Gether	Lundbeck Foundation	Postdoctoral Fellowship Anna Jansen	1.5 mio. DKK	UNIK	Fellowship
Ulrik Gether	FSS (Danish Medical Research Council)	Research grant 2010	3 mio. DKK	UNIK	Research project
Ulrik Gether	National Institute of Health	USA Program Project grant Renewed 2011	3. mio. DKK	UNIK	Research project
Ulrik Gether	FSS (Danish Medical Research Council)	Research Grant	2.9 mio. DKK	UNIK	Research project
Ulrik Gether and Dimitrios Stamou	Lundbeck Foundation	Center of Excellence in Biomembranes in Nanomedicine	34 mio. DKK	UNIK	Research program
Total approx. 445.204.263 (Four hundred and forty five million, two hundred and four thousand, two hundred and sixty three) Danish Kroner					



Appendix B: Center for Synthetic Biology Industrial Relations

Researcher	Industry Partner
Birger Lindberg Møller	Evolva
Birger Lindberg Møller	Pacific Seeds
Birger Lindberg Møller	Christian Hansen
Birger Lindberg Møller	CC Synbio
Birger Lindberg Møller	Carlsberg
Claus Juul Løland	Lundbeck A/S
Dimitrios Stamou	Novozymes A/S
Dimitrios Stamou	Christian Hansen A/S
Jesper Nygard	inXell bionics (own startup)
Jesper Nygard	Sophion Bioscience
Jesper Nygard	Novartis
Jesper Nygard	Microsoft
Jesper Nygard	SunFlake
Karen Martinez	Vipergen (Danish SME)
Karen Martinez	Sophion Bioscience (Danish SME) - NABIIT project CLIPS
Karen Martinez	Novartis (Global Pharmaceutical Company) – NABIIT project ANaCell
Karen Martinez	inXell bionics (own startup)
Karen Martinez	Novo Nordisk A/S – NABIIT project Nanoscreen
Kell Mortensen	JJ-Xray: Udvikling af og forståelse af SAXS apparatur, herunder samarbejde under NABIIT projektet McXtrace.
Kell Mortensen	JJ-Xray / SAXSLab: Udvikling af og forståelse af SAXS apparatur, herunder samarbejde under NABIIT projektet McXtrace.
Kell Mortensen	Arla Food: Struktur af oste og smør produkter.
Kell Mortensen	SABIC T&I, STC Geleen, The Netherlands. Structur bestemmelse af biomolekyler
Kell Mortensen	Grundfos, Struktur og termiske bestemmelse af materialer
Kell Mortensen/Lise Arleth	Novozymes: Diverse small projects on the structure of biomolecules and molecular aggregates.
Lise Arleth	Aquaporin –Helping to solve concrete problems using SAXS, SANS or a combination of these techniques
Lise Arleth	Novozymes - Helping to solve concrete problems using SAXS, SANS or a combination of these techniques
Lise Arleth	Novo Nordisk- Helping to solve concrete problems using SAXS, SANS or a combination of these techniques
Lise Arleth	Gubra - Helping to solve concrete problems using SAXS, SANS or a combination of these techniques
Lise Arleth	Symphogen- Helping to solve concrete problems using SAXS, SANS or a combination of these techniques
Lise Arleth	Ferring- Helping to solve concrete problems using SAXS, SANS or a combination of these techniques
Lise Arleth	Dyrup- Helping to solve concrete problems using SAXS, SANS or a combination of these techniques
Lise Arleth	Haldor Topsøe- Helping to solve concrete problems using SAXS, SANS or a combination of these techniques
Lise Arleth	Rigshospitalet - Helping to solve concrete problems using SAXS, SANS or a combination of these techniques
Lise Arleth	Dupont - Helping to solve concrete problems using SAXS, SANS or a combination of these techniques
Lise Arleth	Aquaporin AS: Dynamic Light scattering experiments (on commercial basis)
Lise Arleth	Novo Nordisk: Nabiit project: Udvikling af microchip til high-throughput strukturelle studier af biomolekyler i opløser.
Lise Arleth	Novo Nordisk: Nabiit project om udvikling af metoder til at forstå og kontrollere nanoskala selvansamling af protein baserede drugs.

Michael Palmgren, Thomas Günther-Pomorski	Pcovery Aps (Danish SME)
Poul Erik Jensen	Dong
Poul Erik Jensen	Haldor Topsøe
Poul Erik Jensen	AlgaFuel SA (PT), Dr. Vitor Verdelho (EU ITN) (SME)
Poul Erik Jensen	Novagreen GmbH (DE), Dr Theodor Fahrendorf (EU ITN) (SME)
Poul Erik Jensen	Algae Biotech (ES), Dr Guido Evers (EU ITN) (SME)
Poul Erik Jensen	LEOPharma (DK), Dr. Thomas Högberg
Seong Wook Yang	Novagreen GmbH (DE), Dr Theodor Fahrendorf (EU ITN) (SME), bio-bunker
Seong Wook Yang	KAERI: Collaboration agreement and patent application. Research grant support for 0.8 million
Thomas Günther-Pomorski	Confidential collaboration with small company (SME); biotechnology/medico
Tom Vosch and Seong Wook Yang	SeouLin Bioscience: Collaboration agreement and patent application. Research grant support for 3 million
Ulrik Gether	Novo Nordisk A/S - ErhvervsPhD Sarah Nørklit Roed
Ulrik Gether	Novo Nordisk A/S - Collaboration with Senior Scientist Maria Woldhoer

Appendix C: Bachelor and Master Students – Synthetic Biology projects. Current and Graduated

Name	Position	Supervisor	Faculty	Project title
Lotte Bettina Andersen	Master	Anja Thoe Fuglsang	SCIENCE	Investigation of the putative trans-activation of the receptor kinase PIRK
Tomas Laursen	Master	Birger Lindberg Møller	SCIENCE	New approaches to study membrane protein complexes
Andre Brannvoll	Master	Birger Lindberg Møller	SCIENCE	A novel method for accelerated cell factory development based on efficient large-scale genome engineering
Rasmus Hilleke	Bachelor	Björn Hamberger	SCIENCE	Diterpene Lactones, unusual plant specialised metabolites that are promising natural pharmaceuticals
Lea Gram Hansen	Bachelor	Björn Hamberger	SCIENCE	Evolution of novel cytochrome P450 families in the medicinal plant <i>Euphorbia peplus</i>
Kim Stroh	Bachelor	Björn Hamberger	SCIENCE	Gene discovery of diterpenes synthases in <i>Nicotiana benthamiana</i>
Henrik Munk Friesenwang	Bachelor	Björn Hamberger	SCIENCE	Mining of cell-type specific next - generation transcriptome data for genes involved in terpenoid biosynthesis
Emil Christian Fischer	Bachelor	Björn Hamberger	SCIENCE	Genomic integration of split-green fluorescent protein in <i>Escherichia coli</i> – a toolbox for synthetic biology
Ida Lauritsen	Bachelor	Björn Hamberger	SCIENCE	Using the ribosomal binding site and the L-rhamnose <i>phaBAD</i> promoter as heterologous expression tools in <i>Escherichia coli</i>
Victor Forman	Bachelor	Björn Hamberger	SCIENCE	Decoupling carbon catabolite repression by insertion of strong promoters in front of L-arabinose transporter genes
Jakob Nybo Nissen	Bachelor	Björn Hamberger	SCIENCE	Product profile of two diterpene synthases is switched by mutation of two amino acids
Josephine Schrøder	Master	Björn Hamberger	SCIENCE	
Christian B Billesbølle	Master	Claus Juul Løland	SUND	Implementation of transition metal ion FRET for short range dynamic distance measurements in LeuT
Louise Freltoft	Master	Claus Juul Løland	SUND	Use of potentiometric fluorophores for determination of ion binding to the LeuT
Jonas Mortensen	Master	Claus Juul Løland	SUND	Characterization of the fluorescence emission signal from TMR-coupled LeuT D192C
Allison D. Fish	Master	Claus Juul Løland	SUND	Characterization of the binding site for atypical dopamine transporter inhibitors
Salome Veshaguri	Master	Dimitrios Stamou	SCIENCE	
Marijonas Tutkus	Master	Dimitrios Stamou	SCIENCE	
Christina Lundgaard	Master	Dimitrios Stamou	SCIENCE	
Ian Allen	Master	Dimitrios Stamou	SCIENCE	
Signe Mathiasen	Master	Dimitrios Stamou	SCIENCE	
Achebe Niels Olesen Nzulumike	Master	Dimitrios Stamou	SCIENCE	
Martin Borch Jensen	Master	Dimitrios Stamou	SCIENCE	
Julie Bomholt	Master	Dimitrios Stamou	SCIENCE	
Jannik Larsen	Master	Dimitrios Stamou	SCIENCE	
Frederik Beyer	Bachelor	Jesper Nygård	SCIENCE	Conductance Measurements on Seed-

Name	Position	Supervisor	Faculty	Project title
				mediated Bottom-up Grown Gold Nanorods
Rune Hviid	Master	Jesper Nygård	SCIENCE	Hafnium Oxide Upgrades pH Sensing InAs Nanowire FET Devices
Rawa Tanta	Master	Jesper Nygård	SCIENCE	Electrical Characterization of Heterostructure Nanowires
Karsten Madsen	Bachelor	Jesper Nygård	SCIENCE	New superconducting contacts to nanotubes
Kasper Laursen	Bachelor	Jesper Nygård	SCIENCE	New superconducting contacts to nanotubes
Liridon Aliti	Bachelor	Jesper Nygård	SCIENCE	Biochips fabricated by UV lithography
Mikkel Nørgaard	Bachelor	Jesper Nygård	SCIENCE	Biochips fabricated by UV lithography
Mustapha Carab	Bachelor	Jesper Nygård	SCIENCE	Biochips fabricated by UV lithography
Luis Caceres Carranza	Bachelor	Karen Martinez	HEALTH	NW arrays and cells
Randi Westh Hansen	Master	Karen Martinez	HEALTH	GPCR in apols & NDs
Rune Frederiksen	Master	Karen Martinez	HEALTH	BioFET
Katrine Rønne Rostgaard	Master	Karen Martinez	HEALTH	NW in cells - NW penetration in cells
Nina Roberts	Master	Karen Martinez	HEALTH	NHERF inetractions with GPCRs
XiaoMei Li	Master	Karen Martinez	KTH, Sweden	NW in cells – cytoskeleton
Gregory Hansen	Master	Karen Martinez	HEALTH	Scaffolding protein and GPCR Ctail
Laila Lhadani	Master	Karen Martinez	HEALTH	Funcionalization with biotin groups of InAs NW for bioFET
Lei Guo	Master	Karen Martinez	SCIENCE	Cell division on NW arrays
Sanjin Kulenovic	Master	Karen Martinez	SCIENCE	Production of native vesicles of mammalian cells
Nina Buch Månson	Master	Karen Martinez	SCIENCE	Functionalization of NW arrays with fluorescent biosensors
Kristian Andersen	Master	Karen Martinez	SCIENCE	Cell migration on NW arrays
Johannes Holm	Master	Karen Martinez	SCIENCE	Enzymatic assays on NW arrays
Andre Diaz	Master (Erasmus)	Karen Martinez	SCIENCE	Immobilization of proteins onto gold electrodes
Valdas Valintalis	Master	Karen Martinez	SCIENCE	NW arrays and membrane curvature in cells
Morten Lykke Hilligsøe	Bachelor	Karen Martinez	SCIENCE	Internalization of GPCRs in living cells
Laura Bojarskaite	Bachelor	Karen Martinez	SCIENCE	BiFC assay
Michele Marioti	Master (Erasmus)	Karen Martinez	SCIENCE	Surface immobilization of nanobodies
Lucy Kundera	Bachelor (Erasmus)	Karen Martinez	SCIENCE	G protein assay
Anna Pie Jacobsen Huda	Master	Lise Arleth	SCIENCE	⁶⁴ Cu-Radiolabelling and In Vivo Studies of Nanodiscs
Nicholas Skar-Gislinge	Master	Lise Arleth, Robert Feidenhans'l	SCIENCE	SAXS and SANS based structural characterization of phospholipid nanodiscs
Francesca Ruggeri	Master	Marité Cardenas	SCIENCE	Effect of protein binding in biological fluids and cell toxicity of nano particles
Elena Nielsen	Bachelor	Marité Cardenas	SCIENCE	Nanoscience
Niklas Bertelsen	Bachelor	Marité Cardenas	SCIENCE	Nanoscience
Tania Lind	Master	Marité Cardenas	SCIENCE	Nanoscience
Danny Mollerup Sørensen	Master	Michael Palmgren	SCIENCE	Functional characterization of orphan pumps using determination of phosphoenzyme kinetics as a tool
Lene Irene Olsen	Master	Michael Palmgren	SCIENCE	Biofortification of the zinc content in plant seeds by modification of heavy metal pumps

Name	Position	Supervisor	Faculty	Project title
Jonas Erik Ilmari Laukkonen Ravn	Bachelor	Peter Naur	SCIENCE	Insertion of soluble, acylated lysozyme and insulin into Nanodisc bilayer membranes, 15 ECTS points
Mike Vestergaard	Bachelor	Peter Naur	SCIENCE	Insertion of soluble, acylated lysozyme and insulin into Nanodisc bilayer membranes, 15 ECTS points
iGEM competition team from 2012 (8 Master students)	Both	Peter Naur		A construct that allows cyanobacteria to emit light when exposed to darkness for an extended period
iGEM competition team, 2011 (8 Master students)	Both	Peter Naur, Björn Hamberger and Johan Andersen Ranberg		A genetically modified Escherichia coli that utilizes the proteins from the family of cytochrome p450s (CYPs) for bioremediation.
Bibi Ziersen	Master	Poul Erik Jensen	SCIENCE	Redirecting solar energy towards new biosynthetic pathways: Microsomal cytochromes P450 expressed in plant chloroplasts
Christine Fredslund	Master	Poul Erik Jensen	SCIENCE	The role of DWARF5, Delta5,7-sterol-delta7-reductase in vitamin D biosynthesis in plants
Peter Klemmed Bjørk	Bachelor	Poul Erik Jensen	SCIENCE	Photosynthetic characterization of transiently transformed tobacco
Morten Hjort Hansen	Bachelor	Poul Erik Jensen	SCIENCE	Manganese deficiency in barley and effects on the photosynthetic apparatus
Josephine Schrøder	Bachelor	Poul Erik Jensen	SCIENCE	Vitamin D synthesis in plants
Peter Skov Kristensen	Bachelor	Poul Erik Jensen	SCIENCE	Coupling of photosystem I to new enzymes
Philip Alstrup Andersen	Bachelor	Poul Erik Jensen	SCIENCE	Photosynthetic biofuels
Anna Holzwarth	Master	Poul Erik Jensen Agnieszka Zygadlo Nielsen	SCIENCE	Investigating the sub-plastidial localization of diterpene synthases inside the chloroplast
Dainius Jakubauskas	Master	Poul Erik Jensen Agnieszka Zygadlo Nielsen	SCIENCE	Combining parts: Fusing ferredoxin to cytochrome P450
Mikkel Christensen	Bachelor	Poul Erik Jensen Agnieszka Zygadlo Nielsen	SCIENCE	Transient expression of diterpene synthases in Nicotiana benthamiana
Marcos Hamborg Vinde	Bachelor	Poul Erik Jensen Agnieszka Zygadlo Nielsen	SCIENCE	Relocating the P450 CYP720B4 into chloroplasts for light-driven synthesis of the diterpene dehydroabietic acid
Freya Minnark-Oddsottir	Bachelor	Poul Erik Jensen	SCIENCE	Impact of manganese deficiency and high light on the photosystem II in Arabidopsis thaliana
Samir Ben Chaabane	Master	Seong Wook Yang	SCIENCE	STA1 is a new player for the splicing of pri-miRNAs in Arabidopsis
Gergana Taleva	Master	Seong Wook Yang	SCIENCE	
Pevel Mitrenga	Master	Seong Wook Yang	SCIENCE	
Anja Ferdinandsen	Master	Seong Wook Yang	SCIENCE	
Ida Louise Jørgensen	Master	Thomas Günther-Pomorski	SCIENCE	Single-vesicle studies of reconstituted membrane pumps
Signe Kaas-Larsen	Master	Thomas Günther-Pomorski	SCIENCE	Nanodiscs – a new tool for studying lipid transport
Maria Martina Ezcurida Koch	Master	Thomas Günther-Pomorski, Rosa L. López Marqués	SCIENCE	Lipid Flippases: Linking lipid transport to vesicle formation
Merethe Mørch Svendsen	Master	Thomas Günther-Pomorski, Rosa L. López Marqués	SCIENCE	Elucidating the regulation of membrane pumps involved in lipid transport and vesicle biogenesis
Andreas Rorvig-	Master	Tom Vosch	SCIENCE	

Name	Position	Supervisor	Faculty	Project title
Lund				
Bjørn Strøm Larsen	Bachelor	Tomas Laursen	SCIENCE	Studying the effect of microenvironment on the proteins involved in the dhurrin pathway Using nanodiscs as platform

Appendix D: Phd and Post Doc Projects

Current Centre for Synthetic Biology Affiliated Phd Projects

Project Title	Name	Advisor	Co-advisors	Financing	Faculty
Project on Formulation and Structural Characterization of Soft Self-Assembled Nanoparticles for Drug delivery	Achebe Nzulumike	Kell Mortensen	Marite Cardenas, Dimitrios Stamou		SCIENCE/HEALTH
X-ray Scattering on Nanoparticles in Microfluidic System	Aghiad Ghazal	Prof. Kell Mortensen	Assoc. Prof. Anan Yaghamur (SUND)	CoNEXT	SCIENCE, PHARMA
Development of an expression platform for purification of eukaryotic NSS proteins	Anne Kathrine Nielsen	Claus Juul Løland		1/3 UNIK	SUND
	Anne Pie Huda	Lise Arleth	Robert Feidenhans'l,	1/3 UNIK 1/3 Sapere Aude 1/3 NBI	SCIENCE
Synthetic biology for light-driven synthesis of diterpenoid	Artur J Wlodarczyk	Poul Erik Jensen	Agnieszka Zygadlo Nielsen	EU FP7 ITN Photo.comm	SCIENCE
Influence of membrane curvature on the structure and function of transmembrane proteins	Asger Tonnesen	Dimitrios Stamou		Lundbeck Foundation	HEALTH
ANACELL; Devices and nanowires for cell studies and bio-devices	Caroline Lindberg	Jesper Nygård	Karen Martinez	ANACELL	SCIENCE
Conformational dynamics of the leucone transporter LeuT	Christian Billesbølle	Ulrik Gether, Claus Løland		UNIK affiliated SUND stipend	SUND
	Jakob Wested				LAW
Chloroplast P450s	Kamil Bakowski	Poul Erik Jensen	Agnieszka Zygadlo Nielsen	CPSC	SCIENCE
NW arrays for cellular assays	Katrine Rønne Rostgård	Karen Martinez	Jesper Nygård, Science	1/3 UNIK	SUND
Synthetic biology of chloroplasts	Konstantinos Vavitsas	Poul Erik Jensen	Agnieszka Zygadlo Nielsen	CPSC	SCIENCE
	Kristian Moss Bendtsen				SCIENCE
Identification and characterization of cytochromes P450 and glucosyl transferases involved in synthesis of cyanogenic glucosides and other hydroxynitrile glucosides in sorghum, cassava, Lotus japonicus, and eucalyptus	Krutika Bavishi	Birger Lindberg Møller	Jean-Etienne Bassard	EU Marie Curie UNIK affiliated	SCIENCE

Project Title	Name	Advisor	Co-advisors	Financing	Faculty
Scaffolding enzymes in the chloroplast	Maria Perestrello Ramos H de Jesus	Poul Erik Jensen	Agnieszka Zygadlo Nielsen	DSF: Plant Power	SCIENCE
Endogenous turnover of cyanogenic glycosides in almond and cassava	Martina Picmanova	Birger Lindberg Møller	Kirsten Jørgensen	EU Marie Curie UNIK affiliated	SCIENCE
High resolution fluorescence microscopy for nanometer accurate positioning	Morten Karlsen	Ulrik Gether	Thomas Bjørnholm	1/3 UNIK	SUND
The BAR domain module PICK1: a possible tool in synthetic biology	Morten Lundin Karlsen	Ulrik Gether	Lise Arleth, Kenneth Lindegaard Madsen	1/3 UNIK 2/3 Star Program 1/3 ny SUND-bevilling	SUND
NW arrays for cellular assays	Nina Buch Månson	Karen Martinez	Jesper Nygård, Science	ANaCell – affiliated to UNIK	SUND
Quantitative investigations of GPCR signaling in a isolated system	Randi Westh Hansen	Karen Martinez		1/3 UNIK 1/3 Lundbeck 1/3 DIMP project/DRC	SUND
Electron beam lithography for nano fabrication	Rawa Tanta	Jesper Nygård	Per Hedegård,	300.000 DKK UNIK Remaining sum: the candidate's stipend from Syria	SCIENCE
Imaging NW arrays	Rune Frederiksen	Karen Martinez	Jesper Nygård, Science	1/3 UNIK	SUND
Single molecule conformational dynamics of GPCRs	Salome Veshaguri	Dimitrios Stamou		Lundbeck Foundation	SCIENCE
Crosstalk between microprocessor and spliceosome complex in plants	Samir Ben Chaabane	Seong Wook Yang		1/3 UNIK 2/3 Korean collaboration	SCIENCE (Former LIFE)
Neuronal scaffolding proteins in synthetic biology	Simon Erlendsson			50% UNIK	SUND/Science
Structure, function and membrane interactions of PICK1	Simon Erlendsson	Kaare Teilum, and Ulrik Gether			SCIENCE and SUND
New Ag and Au clusters based fluorophores for fluorescence microscopy applications	Simon Gregersen	Knud J. Jensen	Tom Vosch	1/3 UNIK, 1/3 LIFE	SCIENCE (Former LIFE)
Investigation of photoconversion and spectral heterogeneity of fluorophores	Zhiyu Liao	Tom Vosch		1/3 UNIK	SCIENCE
Elucidating the mechanism of actions of novel antimicrobial peptidic dendrimers	Tania Kjellerup Lind	Marité Cardenas	Hanna Wacklin (ESS)	ESS (salary); dept of Chem (OH)	SCIENCE
Terpenoids; their effect on	Vivien	Marité	Bjørn	BioSynergy	SCIENCE

Project Title	Name	Advisor	Co-advisors	Financing	Faculty
lipid membranes	Jagalski	Cardenas	Hamberger; Birger lindberg Møller		
	Andreas Therkelsen Christensen	Sune Holm		BioSynergy	HUM

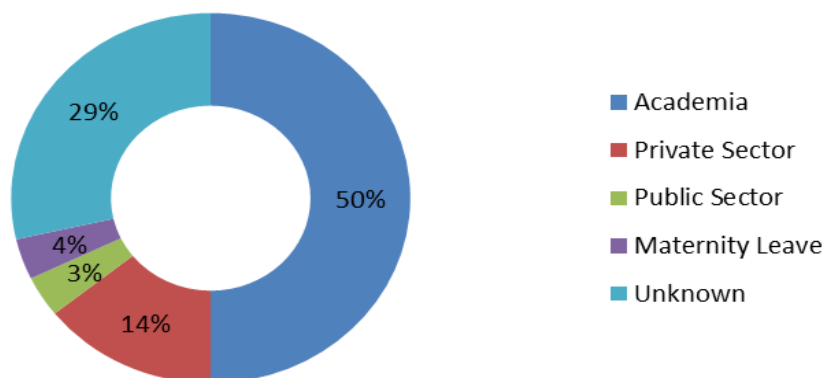
Centre for Synthetic Biology Affiliated Phd Graduates

Project Title	Name	Advisor	Co-advisors	Financing	Faculty	Graduation date	Current Position
Applications of nanovesicles in nanomedicine	Andreas Lauge	Dimitrios Stamou		DSF	SCIENCE		
Investigations of nanodiscs on water and solid surfaces by means of X-ray and neutron scattering techniques	Maria Wadsäter (Svensson)	Marite Cardenas	Jens Bæk Simonsen Lise Arleth Kell Mortensen Marité Cárdenas Robert Feidenhans'l	1/3 SCIENCE 1/3 LIFE 1/3 UNIK	SCIENCE		Research Scientist at Lund University /Camurus
Scaffold proteins and GPCRs in vitro	Thor Møller	Karen Martinez		KU prog of excellence -affiliated to UNIK		September 2012	Post-doc Montpellier France (Marie Curie stipend)
Scaffold proteins and GPCRs in cells	Volker Wirth	Karen Martinez		KU prog of excellence affiliated to UNIK	SUND	March 2014	Patent lawyer office - Germany
Nw arrays and cells	Trine Berthing	Karen Martinez		Research Council - affiliated to UNIK		April 2013	Maternity leave - unemployed
Glutamate based biosensors	Nathalie Rieben	Karen Martinez		Research Council - affiliated to UNIK	SUND	September 2010	Employed at Copenhagen commune (admin)
BioFET	Yi-Chi Liu	Karen Martinez		Research Council - affiliated to UNIK	NAT	September 2011	Postdoc Nanyang Technological University - Singapor
Development of novel type of biosensor for glutamate using biosensor field effect transistors	Noemie Lloret	Karen Martinez		1/3 UNIK, 1/3 SUND	SUND	September 2013	Unemployed
Development of stealth carrier systems for membrane proteins	Selma Maric	Lise Arleth		1/3 UNIK, 1/3 European Spallation	SCIENCE (Former LIFE)	February 2014	Post doc at Karolinska Institut, Sweden

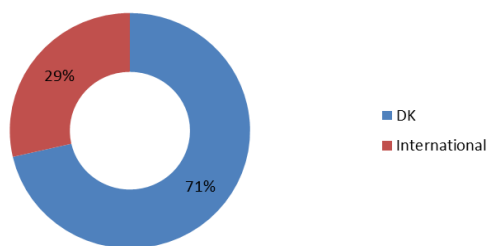
				Source, 1/3 LIFE			
Unravelling the structure and dynamics of the proton pump signalosome	Christian Oehlenschläger	Anja Fuglsang	Michael Palmgren	1/3 UNIK, 1/3 LIFE, 1/3 PUMPKIN	SCIENCE (former LIFE)	June 2014	Scientific Researcher at Novozymes
Reconstitution of a pump-signalosome in liposomes and giant liposomes	Lisa Theorin	Thomas Günther-Pomorski	Anja Thoe Fuglsang, Michael Palmgren	1/3 UNIK, 1/3 LIFE, 1/3 PUMPKIN	SCIENCE (Former LIFE)	May 2013	Postdoc with Thomas Günther-Pomorski; now back to Sweden working
Analysis of protein-membrane interactions – A liposomal approach	Gerdi Kemmer	Thomas Günther-Pomorski	Anja Thoe Fuglsang	LIFE	SCIENCE (Former LIFE)	February 2014	Now Postdoc with Thomas Günther-Pomorski
Structural and functional studies of a pump-signalosome reconstituted in nanodiscs	Bo Højen Justesen	Anja Thoe Fuglsang	Michael Palmgren, Thomas Günther-Pomorski	LIFE	SCIENCE (Former LIFE)	March 2013	Postdoc with Thomas Günther-Pomorski
The role of signalling pathways in plants	Johan Andersen-Ranberg	Björn Hamberger		2/3 UNIK, 1/3 LIFE	SCIENCE (Former LIFE)	June 2014	Post Doc at Department of Plant and Environmental Sciences
Light Sensing Nanosensor for Inhibitor Screening	Pratik Shah	Seong Wook Yang		2/3 UNIK, 1/3 LIFE		June 2014	
Conformational changes of cytochrome P450 reductase in cytochrome P450 reactions	Tomas Laursen	Birger Lindberg Møller	Nikos Hatzakis,		2/3 UNIK, 1/3 LIFE	February 2014	Post Doc at Department of Plant and Environmental Sciences
Elucidation of the Vanillin Biosynthetic Pathway in <i>Vanilla planifolia</i>	Nethaji J Gallage	Birger Lindberg Møller	Esben Halkjær, Rubini Kannangara			June 2014	Post Doc at PLEN – Maternity leave
	Jonas Willum Nielsen				SCIENCE		
Roles of Hydroxynitrile Glucosides in Barley	Pernille Sølvhøj Roelsgaard	Birger Lindberg Møller	Kirsten Jørgensen, Michael Lyngkjær		SCIENCE		May 2014
Share your parts-Synthetic Biology:From sunlight to hydroxylated complex bio-active natural products	Lærke Münther Lassen	Poul Erik Jensen	Birger Lindberg Møller	1/3 VKR, 1/3 LIFE, 1/3 UNIK	SCIENCE (Former LIFE)		Post Doc at Department of Plant and Environmental Sciences
Artificial light driven machines	Dong Shi	Bo Wegge Laursen		1/3 UNIK	SCIENCE		Post Doc at: Solar and Photovoltaic Engineering Research Center King Abdulah University of Science of Technology

							(KAUST)
Light driven biosynthetic pathways using <i>Nicotiana benthamiana</i> as host	Thiyagarajan Gnanashekar	Poul Erik Jensen	Birger Lindberg Møller, Agnieszka Zygadlo Nielsen		SCIENCE (Former LIFE)		Research Assistant at PLEN
Development of methods and software tools for the determination of 3D-structures of membrane proteins from small-angle scattering data	Martin Cramer Pedersen	Kell Mortensen	Lise Arleth	1/3 LIFE 1/3 UNIK 1/3 McXtrace	SCIENCE	June 2014	Research Assistant / postdoc at Niels Bohr Institute, X-ray and Neutron Science
SAXS, Reverse Monte Carlo and Nanodisc's	Søren Kynde	Kell Mortensen	Lise Arleth		SCIENCE (Former LIFE)		Post Doc at Niels Bohr Institutet, X-ray and Neutron Science.
	Aparajita Singh	Nikos Hatzakis	Dimitrios Stamou, Birger Lindberg Møller		SCIENCE		
Monitoring the function of single nanoscale pump-signalosomes	Christina Lohr	Dimitrios Stamou	Anja Thoe Fuglsang Michael Palmgren Thomas Pomorski	1/3 UNIK 1/3 SUND 1/3 STAR	SUND	February 2014	
Theoretical rationalization of the measure	Martin Hediger	Jan H. Jensen	Karen Martinez Jesper Nygård	1/3 UNIK 1/3 EU 1/3	SCIENCE		Theoretical rationalization of the measure
Hardwiring photosystem I	Sune Klamer-Jørgensen	Thomas Bjørnholm	Poul Erik Jensen, Bo Wegge Laursen, Jesper Nygård	1/3 LIFE, 1/3 UNIK, 1/3 VKR Proactive Plants	SCIENCE	October 2013	
Using Nanodiscs to facilitate structural studies of membrane proteins with Small-Angle Scattering	Nicholas Skar-Gislinge	Lise Arleth	Kell Mortensen Robert Feidenhans'l	1/3 Research School for Molecular Biophysics (SDU) 1/3 LIFE 1/3 UNIK	SCIENCE (Former LIFE)		Post doc at Novozymes
Optimization of belt-proteins for nanodisc formation	Søren Roi Midtgaard	Knud J. Jensen	Lise Arleth Kell Mortensen	1/3 UNIK	SCIENCE (Former LIFE)	April 2013	Administrative Officer at Niels Bohr Institutet, X-ray and Neutron Science
Hardware and electrical measurements for the nanowire biosensor platform	Shivendra Upadhyay	Jesper Nygård	Karen Martinez, Jan H. Jensen	1/3 UNIK, 1/3 SCIENCE, 1/3 KU	SCIENCE		

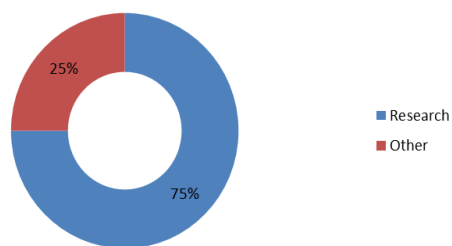
Phd Graduate Sectors



Academia



Private Sector



Current Centre for Synthetic Biology Affiliated Post Doc Projects

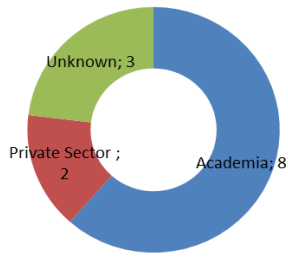
Project Title	Name	Advisor	Financing	Faculty	Start date
Protein organization in plant specialised metabolite pathways	Jean Etienne Bassard	Björn Hamberger	UNIK	SCIENCE (Former LIFE)	
Discovery and characterization of functional parts of the synthesis of bioactive diterpenoids in medicinal plants	Eirini Pateraki	Björn Hamberger	Marie Curie Intra-European Postdoc fellowship- UNIK affiliated	SCIENCE (Former LIFE)	
INfluence of membrane curvature on Ras localization in living cells	Alexander Damalas	Dimitrios Stamou	Lundbeck Foundation	SCIENCE	
Single molecule enzymology		Dimitrios Stamou	Lundbeck Foundation	SCIENCE	
Nw arrays and cells	Sara Bonde	Karen Martinez	Research Council	SCIENCE	Will leave in August 2014
Electrical platform for protein arrays	Eduardo Della Pia	Karen Martinez	Research Council	SCIENCE	
Nw arrays and cells	Maeva Vignes	Karen Martinez	Research Council	SCIENCE	
Investigations of nanodiscs	Jens Bæk Simonsen	Kell Mortensen	2 ½ year partly from UNIK	SCIENCE (Former LIFE)	

Processing mechanism for miRNA biogenesis. Cell cycle manipulation of micro-photosynthetic organisms for the production of bio-bunker	Seok Keun Cho	Seong Wook Yang	Seoulin collaboration grant, UNIK synbio, FTP 2014	SCIENCE	Oct. 2012
Functional analysis of RING E3 ligase for drought resistance. Remediation of CsCl using plants	Moon Young Ryu	Seong Wook Yang	KAERI collaboration grant	SCIENCE	August 2014
DNA-templated AgNCs sensors for miRNA detection	Pratik Shah	Seong Wook Yang	UNIK synbio	SCIENCE	July 2014
Structural determinants of G protein subtype specificity for G protein coupled receptors	Xavier Kubiak	Søren Gøgsig Faarup Rasmussen	FSS	SUND	November 2012
Mapping potential legal challenges of synthetic biology and debating selected legal issues that show greater practical relevance for the European and Danish synthetic biology community and society at large.	Ana Nordberg	Timo Minssen		LAW	April 2014
Molecular analysis of P-type ATPases from single vesicle to single molecule level	Gerdi Kemmer	Thomas Günther-Pomorski	3 years, FNU Research Council	SCIENCE (Former LIFE)	February 2014
Structural and functional studies of a pump-signalosomes reconstituted in nanodiscs	Bo Højen Justesen	Thomas Günther-Pomorski	2 years, UNIK F16, BioSYnergy	SCIENCE (Former LIFE)	March 2014
The role of signalling pathways in plants	Johan Andersen-Ranberg	Björn Hamberger	2/3 UNIK, 1/3 LIFE	SCIENCE (Former LIFE)	June 2014
	Agnieszka Zygodlo Nielsen				
	Tomas Laursen				Mar 2014
	Grethe Vestergaard Jensen			SCIENCE	
	Deyang Xu			SCIENCE	

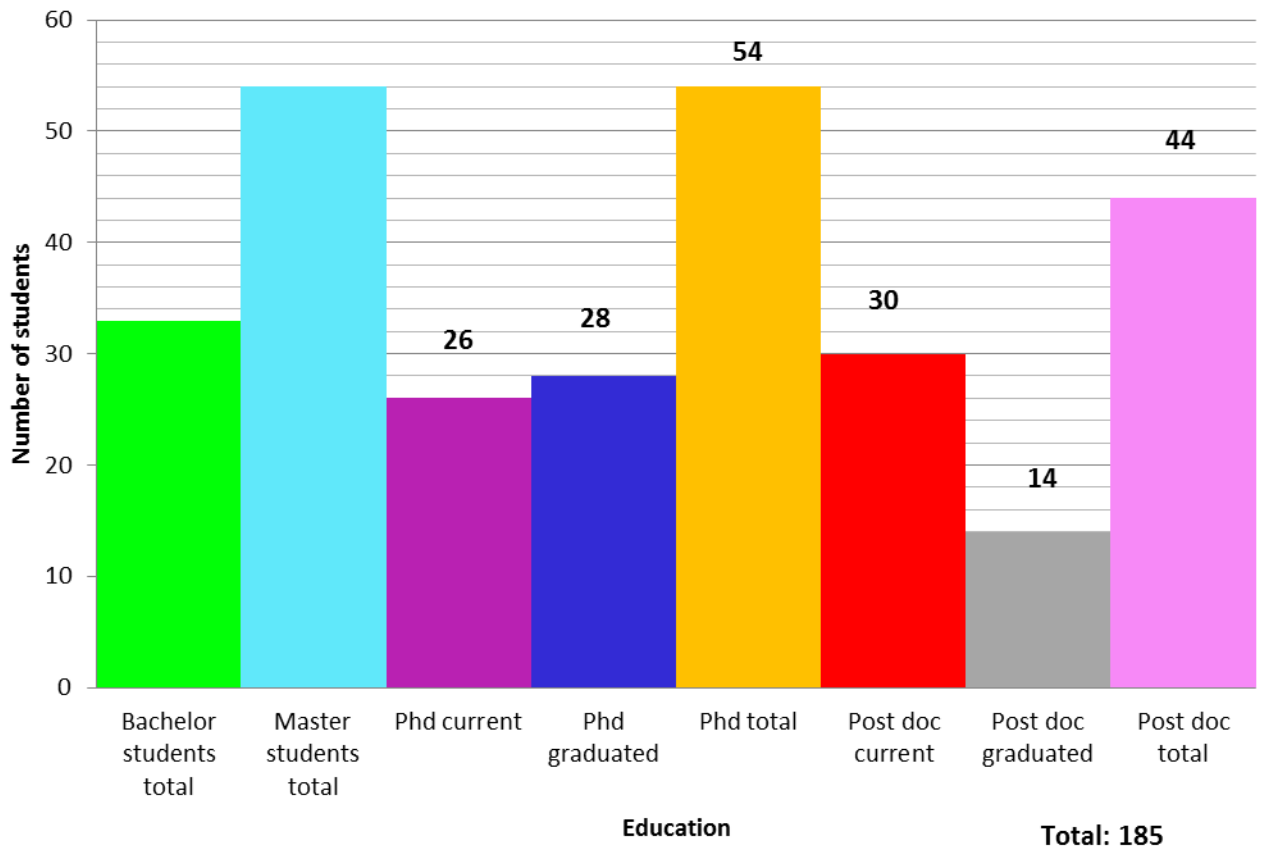
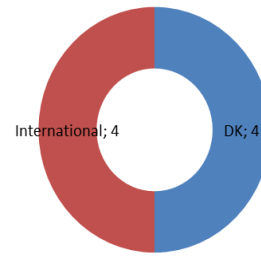
Centre for Synthetic Biology Affiliated Post doc Graduates

Project Title	Name	Advisor	Financing	Faculty	Graduation date	Current Position
Single molecule measurements of Ras mediated GTP catalysis	Lars Iversen	Dimitrios Stamou	Lundbeck Foundation	SCIENC E		Ass. Professor, Department of Chemistry, KU
Scaffold proteins and GPCRs in vitro	Thor Møller	Karen Martinez	6 MM UNIK	SCIENC E	December 2012	Postdoc at Institute de Génomique Fonctionnelle
Chiral and polycontinuous mesostructures from multicomponent star molecules	Jacob Judas Kain Kirkensgaard	Kell Mortensen	UNIK Lundbeck Foundation	SUND	April 2014	Ass. Professor, NBI, KU
Valorisation of potato pulp	Jesper Harholt	Peter Ulvskov	Danish National Advanced Technology Foundation	Science		Ass. Professor, PLEN, KU
Analysis of protein-protein interactions in inverted membrane sheets	Thor Thorsen	Ulrik Gether Kenneth Lindegaard Madsen	1 year 100% UNIK	SUND		
Development of Nanodiscs as a platform for structural studies of membrane proteins in solution	Rasmus Høiberg-Nielsen	Lise Arleth	2 year 100% Lundbeck	SCIENC E (Former LIFE)		
Structural and functional analysis of LeuT reconstituted into nanodisks	Nadia Cherouti	Ulrik Gether Claus J. Løland	2 ½ years 100% UNIK	SUND		Senior Scientist at MipSalus
	Signe Mathiasen	Dimitrios Stamou		SCIENC E (KEMI)		Postdoc at Columbia University, New York
	Kenneth Lindegaard Madsen			SUND		Ass. Professor, INF, KU
	Marta Powikrowska	Erik Jensen ?		PLEN		
	Mette Rathje			SUND		Post Doc MIT
	Ina Ammendrup			SUND	April 2012	Postdoc at University of British Columbia
Structural determinants of G protein subtype specificity for G protein coupled receptors	Christine Oswald	Søren Gøgsig Faarup Rasmussen	Lundbeck	SUND		Heptares therapeutics, UK
GPCR in nanodiscs	Xiaole Wang	Karen Martinez	12 MM UNIK	SCIENC E	June 2014	

Post doc graduate sectors



Academia



Appendix E: Media Exposure

External Exposure:

Center for Synthetic Biology scientists and science featured in external media

Center for Synthetic Biology has been featured a total number of 205 times in external media.

This consists of:

Print media exposure: 91 features have been exposed to a minimum of 2.835.000 readers

TV exposure: 4 features have been exposed to a minimum of 1.238.000 viewers

Radio exposure: 12 features have been exposed to a minimum of 204.000 listeners

Online (non-social media) exposure: 85 features have been exposed on websites which put together have a minimum of 17.150.000 viewers per month

Social media exposure: 13 features have been exposed to a minimum of 14,573 viewers

Exhibitions: 2 features have been exposed to a minimum of 30.000 visitors

Total exposure: 204 features have been published in media with a combined estimated readership of 4.691.573 people excluding the stories on Science Daily and PhysOrg (see below)

One story ([Advance in Re-Engineering Photosynthesis to Make Drugs, Compounds or Ingredients](#)) has been featured on the [Science Daily Website](#) with an estimated readership of 15 million viewers per month.

One story (“[Advance in re-engineering photosynthesis to make drugs, compounds or ingredients](#)”) has been featured on the [PhysOrg](#) website with an estimated readership of 1.75 million viewers per month

International exposure: 37 features exposed on websites with an estimated minimum of 16.8 million viewers per month.

Estimation of readerships:

Numbers for Print media, TV and Radio are based on the most authoritative source of media intelligence surveys in Denmark: Tns-Gallup.dk. Numbers for Online and Social Media are based on the self-reporting of the individual websites where available. A large number of websites do not have readerships numbers available, thus making the total estimated readership below the actual number of readers/participants.

Print media and newspaper websites

Total exposure in print media and newspaper websites 91 features exposed to a minimum of 2.835.000 readers:

Where / When	Media Type	Number of stories	Readership	Story
Aktuel Naturvidenskab	National Popular Science magazine	2		
2013				Drevet af lyset - fotosyntesen på arbejde
2011				Biologen på arbejde - dansk satsning på syntesebiologi
Berlingske	National Newspaper	7	247,000 readers quarterly	
2014				Forskere finder 'opmærksomheden' i hjernen
2013				Brug forskning til at skabe vækst
				Navnlig navne – Claus Juul Løland
2012				Forskning på Københavns Universitet skal gøre verden til et grønnere sted
				Selvlysende DNA finder genetiske spor
				Biotekselskab skifter fra medicin til ingredienser
				De fattiges foderplante gjort giftfri
BT	National Newspaper	1	242,000 readers quarterly	
2012				SUNDHED: Forsker-hjælp til overvægtige
Børsen	National Newspaper	3	173,000 readers quarterly	
2013				På toppen af fødevarerpyramiden
2012				Lykkelige i nørddland
2010				UNIK hæver dansk grundforskning til verdenseliten
DI Business 2014	Weekly magazine about business politics published by Danish Industry	1		Piloter viser potentiale
Frederiksborg Amts Avis	Regional Newspaper	2	57,000 readers quarterly	
2013				Støtte til forskning
2010				Forskningsstøtte – Claus Juul Løland (full text not available)
Ingeniøren	Specialized Newspaper	7	156,000 readers quarterly	
2014				Dansk forsker afdækker kræftcellers skjulte 'Formel 1-kommunikation'
2013				Ny produktion af malariamedicin kan være skadeligt for miljøet
				Foerende dansk planteforsker: GMO er blevet en slagmark
				Novozymes sponsorerer danske biohackere

Where / When	Media Type	Number of stories	Readership	Story
				Prøv det selv - ny udstilling går tæt på biohacking
2012				Danske forskere vil omdanne planters grønkorn til medicinfabrikker
				Danske forskere sætter fedtnedbrydende enzymer på overarbejde
Information	National Newspaper	10	105,000 readers quarterly	
2014				Mangfoldig uddannelse
				På tur i en skov af patenter
				Forskning for folket
				Patenter kan også skabe videndeling
2013				Den lille mand vandt
				Professor i samarbejde med biohackere
2012				Da forskerne kom op i elfenbenstårnet
				Fakturaen mangler
2011				Syntesebiologi er mange ting
				Vi kan lave jetbrændstof med syntetisk biologi
Jyllands-Posten	National Newspaper	8	331,000 readers quarterly	
2014				Ny nano-viden kan give bedre medicin
2013				NAVNE I NOTER – Claus Juul Løland
2012				Glad for arbejde?
				Enzym-opdagelse kan forandre dit liv
				Enzymer kan fjerne overvægt
2010				Vi skal satse på syntesebiologi
				Navne – Claus Juul Løland
				NAVNE I NOTER-Lise Arleth
Jydske Vestkysten 2012	Regional Newspaper	1	173,000 readers quarterly	Københavnske forskere har gode nyheder til overvægtige
Kemivärlden Biotech – Kemisk tidskrift (Swedish) 2011	Specialized News Magazine	1	9,000 readers pr. week	Våra framtida kemikaliefabriker
Kristeligt Dagblad	National Newspaper	4	105,000 readers quarterly	
2014				Hun viser vejen til fremtidens forskning
				Har vi stadig brug for et etisk rådgivende organ?
2013				Ny viden om depressioner
2010				Fondsmidler til nervecelleforskning
LifeSciences Insight 2012	Specialized News Magazine	1	60,000 pr. year	Spotlight on Synthetic Biology (full text unavailable)
Metro Express 2012	National Newspaper (free)	1	340,000 readers quarterly	Kroppens egne enzymer skal fjerne overvægt
Midtjyllandsavis 2012	Regional Newspaper	1	34,000 readers quarterly	Kroppens enzymer skal fjerne overvægt

Where / When	Media Type	Number of stories	Readership	Story
Nordjyske Stiftstidende	Regional Newspaper	4	138,000 readers quarterly	
2014				Nye Medlemmer af ATV
				Sundhedsnyt fra blade og aviser er utroværdigt
				Beskeden tro på gode råd om sundhed
2012				Amerikansk kemipris til dansk professor
Politiken	National Newspaper	7	353,000 readers quarterly	
2014				Sindrig hormonmekanisme virker som en dirigent
				Samfundet har hårdt brug for de æstetiske fag
2013				Københavns Universitet investerer stort i kemi
				Forskere finder kokainkontakt i hjernen
2012				Hvad forsker du i: Hjernens kringlede signalstoffer
				Danske forskere sætter fedtædere på overarbejde
				Længere arbejdstid til enzymer, der æder vores fedt
				Forsker: Fedtpillen er ikke lige om hjørnet
Research Europe	International Research and Policy magazine	2	20,000 readers quarterly	
2013				Danish amateur biology group looks to upgrade following industry donation
				Copenhagen teams up with biohackers
The Copenhagen Post	Danish news in English	1		Inspiration for a go-get-'em generation
Universitetsavisen	University of Copenhagen newspaper in Danish	1		Se navene på KUs hotteste forskere
University Post	University of Copenhagen newspaper in English	6	49,000 readers quarterly	
2014				Copenhagen team preparing for global biology clash at iGEM
2013				Students to compete in synthetic biology in France
				Copenhagen students took gold in France
				Hands on learning in DIY biology competition
2012				Kvinder gør en forskel i forskning
2010				Priser – Claus Juul Løland
Vejle Folkeblad 2012	Regional Newspaper	1	55,000 readers quarterly	Kroppens egne enzymer skal fjerne overvægt
Viborg Folkebladet 2012	Regional Newspaper	1		Københavnske forskere har gode nyheder til til overvægtige
Weekendavisen	National Newspaper	8	257,000 readers quarterly	

Where / When	Media Type	Number of stories	Readership	Story
2013				Videnskab for gentlemen
				Når maskiner bliver levende (full text not available)
2012				Mændene, der fandt cellernes øjne
				En plante tænker sit
				Grønne Produktionshaller
				Viden i alle lande, foren den!
2011				Celler på spid
2010				De bygger med biologi
2009				Kvantemekanik: Tvillinger I fysikkens verden

TV

Total TV exposure: 4 features have been exposed to a minimum of 1.238.000 viewers

Where / When	Media Type	Number	Readership	Story
DR TV – 21 Søndag	National TV Station	2	946,000 viewers per show	
2013				Folket er de nye forskere
2010				Studerende misbruger ADHD-medicin
TV2 News 2012	National TV Station	1	292,000 viewers per show	Synthetic Biology Professor speaking at TEDxCopenhagen 2012
TV2 Lorry 2012	Local News Station	1		Ny plante er et gennembrud

Radio

Total radio exposure: 12 features have been exposed to a minimum of 204,000 listeners

Where / When	Media Type	Number	Readership	Story
DR P1	National Radio Station	7	204,000 listeners per day	
2013	Morgen			Synbio Interview – Birger Lindberg Møller
2012	Morgen			Report on dhurum research
				Interview med Søren Gøgsig Faarup Rasmussen, Nobel prisen i kemi 2012
	Sundhed på P1			Kokain, Parkinsons & Ludomani
2011	Videnskabens Verden			Når nørder nørder
	Videnskabens Verden			Nørdernes fest
2010	Morgen			Kokainens virkning – Claus Juul Løland
JP Radio	Jyllands Posten's national radio station	1		Forskningspolitik 3: Globale Trends og nye samarbejdsformer
Radio24syv	National Radio Station	4		
2012				Report on Birgitte Gohm Hansen's Phd thesis 'Adapting in the Knowledge Economy: Laternal Strategies for Scientists and Those Who Study Them'

Where / When	Media Type	Number	Readership	Story
				Copenhagen Do It Yourself biology scene
				Interview with Birger Lindberg Møller. Open PCR machine
				Nobel sprise i kemi 2012 i programmet 3. Planet fra solen

Online (non-social media websites)

Total online exposure (non-social media): 85 features have been exposed to a minimum of 17,150,000 viewers

Where / When	Media Type	Number	Readership	Story
Agency for Science and Innovation website	Danish Governmental homepage	2		
2012				Danish synthetic biology at the forefront in China (link removed)
2011				Ny dansk-californisk alliance om fremtidens bio-samfund (link removed)
Act In Biotech 2013	French Biotech news website	1		Biologie « Open Source » : une collaboration inhabituelle entre professeurs et biohackers
Altinget.dk	Online newspaper focusing on Danish politics	5		
2014				To nye formænd i Det Frie Forskningsråd
2013				Lektor Claus Juul Løland modtager stor donation fra Lundbeckfonden
2012				Lundbeckfonden støtter forskning i lægemidler
2010				Claus Juul Løland modtager 1,6 mio. kr.
2009				Lundbeckfonden: 34 mio. kr. til center for nanomedicin
ATV.dk 2014	The Danish Academy for Technical Sciences homepage	1		40 nye medlemmer optaget i ATV
Avisen.dk 2012	Online newspaper with focus on Danish work life	2		Enzymer skal æde vores fedt væk
				Danskere knækker kokainens kode
Biofuel Daily 2013	Biofuel news website	1		Using photosynthesis to make chemical compounds
Bright Surf.com 2013	Science news and events website	1		Advance in re-engineering photosynthesis to make drugs, compounds or ingredients
Bulletins-electroniques.com	French Technology news website	1		Biologie "Open Source" : une collaboration inhabituelle entre professeurs et biohackers
Chemistry 2011 2013	Chemistry Education website	1		Advance in re-engineering photosynthesis to make drugs, compounds or ingredients
DagbladetRingSkjern.dk 2012		1		En nobelpris til min disciplin
Dagens Medicin	Website for Medical Doctors	3		

Where / When	Media Type	Number	Readership	Story
2012				Stor lægepris for forskning in hjernens signalsystemer
2011				Dansk nanoteknologi kan bane vejen for hurtigere medicinudvikling
2010				1,6 mio. kr. til forskning i nervesignalstoffer
2009				10 mio. kr. til etablering af forskningsgruppe på SUND, Søren Gøgsig Faarup Rasmussen
Dansk Film Institut 2014	Danish Film Institute's website	1		Film og forskning i eksperimenterende parløb
Danish Ministry of Science, Innovation and Higher Education 2012	Danish Governmental homepage	1		Dansk syntesebiologi bygger bro til Kina
Det Ethiske Råd	Danish Ethical Council's Homepage	6		
2013				Syntesebiologi-Debatoplæg
2012				Syntesebiologi – design af organismer
				Etik-Syntesebiologi
2011				Debat om syntesebiologi
				Kunsten at bygge med liv
				Kom til debat om syntesebiologi
DJØF Bladet 2014	Member magazine of professional union	1		Forskerne uenige om, hvad ansvarlig forskning er
DR Viden 2014	Research page of national TV provider DR's website	1		Spadestik i Lund er milepæl for forskere og industri
EurekAlert! 2013	Online, global news service operated by AAA	1		Advance in re-engineering photosynthesis to make drugs, compounds or ingredients
European Parliament: Science and Technology Options Assessment Homepage	Homepage of STOA	3		
2012				Synthetic biology - enabling sustainable solutions for food, feed, bio-fuel and health: New potentials for the European bio-economy
				STOA workshop in cooperation with the University of Copenhagen and the Technical University of Denmark
				Synthetic biology: New potentials for the European bio-economy
folketidende.dk 2012	Online newspaper serving Lølland-Falster	1		Kroppens egne enzymer skal fjerne overvægt
Forsker Forum 2014	Magazine for members of the Danish Masters' Union	1		Årets KU-underviser giver kemi-lektier for på video
Morsø Folkeblad 2012	Online regional newspaper	1		Kroppens egne enzymer skal fjerne overvægt

Where / When	Media Type	Number	Readership	Story
Innovation Center Denmark website 2012	Newsreel. Ministry of Foreign Affairs in Denmark homepage.	1		Danish synthetic biology at the forefront in China
Journalisten.dk 2014	A member magazine published by the Danish Journalism Association	1		Alt er kommunikation
Kommunikationsforum.dk 2012	Online communication forum	1		Speakerteknik I Topklasse: 6 Tedx-Pointer
Life Science Sweden 2009	Online biotech news site	1		Ny metod ger bild av nervsignal
Medical Museion 2013	Homepage of museum and research unit at the University of Copenhagen	1		Biohacking – Do It Yourself!
MedIndia 2013	Medical news and information website	1		Research Highlights Advance in Re-Engineering Photosynthesis to Make Drugs, Compounds or Ingredients
MedWatch 2014	Online news site focusing on the medical industry	7		Afløseren til Danmarks Forskningspolitiske Råd på plads
				Små firmaer kan få et vanskeligt liv under den nye patentdomstol (full text unavailable)
				Forskere er uenige om begrebet ansvarlig forskning
				Kan KU optimere Novo-medicin?
				Universiteter bejler til firma-forskere i milliardprojekt
2012				Fedtpillen: Den er ikke lige om hjørnet
				Længere arbejdstid til enzymer, der æder vores fedt
Nanotechweb.org 2014	A community website from IOP publishing	2		Bionanotechnology: Arrays in the future prospects of the field
				Reviewing the prospects of nanostructures in biological research
Network Society.org 2012	Homepage of project investigating knowledge sharing	1		Birger Lindberg Møller: DK network
Newspaq 2012	Danish news bureau	1		Enzymer skal æde vores fedt væk
Pharma Danmark 2010	An association of Pharmaceuticals professionals	1		Forskning i overhalingsbanen
PhysOrg 2013	Web-based science, research and technology news service	1	1.75 million views per month	Advance in re-engineering photosynthesis to make drugs, compounds or ingredients

Where / When	Media Type	Number	Readership	Story
Scandasia.com 2012	News for Scandinavians in Asia	1		Danish synthetic biology at the forefront in China,
Science Daily 2013	Science news web sites.	1	15 million page views per month	Advance in Re-Engineering Photosynthesis to Make Drugs, Compounds or Ingredients
Studiolab 2013	EU funded art and science project	1		Doing and Debating DIY Biology at Medical Museion: Workshop
Synbiology.co.uk 2013	Synthetic Biology online news website	1		Re-engineering photosynthesis to make drugs, compounds or ingredients
Technology.org 2013		1		Re-Engineering Photosynthesis
Tedx copenhagen.dk	Website of Independently organised TED event	2		
2012				Talks: Plant Power: The Ultimate Way To Go Green
				Speakers: Birger Lindberg Møller
Teknik og Viden 2012	Online research news	1		Unge kvinder i forskning modtager legater
The Medical News 2013		1		Advancement in re-engineering photosynthesis can transform plants into bio-factories
Teknologi Rådet 2013	Danish Board of Technology's Homepage	1		Synthetic biology for debate
TV2 News webpage 2012	National TV station website	1		Tænd og sluk for fedtet i din krop
Tænk 2012	Consumer site	1		Du Kan Købe Nanoprodukter Uden At Ane Det
US News 2012	US news site reporting US and global news	1		Super Plants: Could Re-Wired Plants Be the New Cancer Killers?
Videnskab.dk	Online news outlet disseminating Danish and international research stories	16	400,000 per month	
2014				Alger skal være fremtidens grønne fabrikker
				Hvem skal bestemme, hvad der skal forskes i?
				Hackerspaces kan give os en ny læringskultur
				Derfor har man svært ved at holde opmærksomheden
				Forskere finder link mellem parkinsonisme og ADHD hos én patient
				Kan verden 'vejes' visuelt
				Hvordan påvirker kokain hjernen?
2013				Forskeres rolle i medierne ændrer sig
2012				KU i Kina
				Forskere finder tænd/sluk-knap til overvægt

Where / When	Media Type	Number	Readership	Story
				Fornem hæder til kvindelige forskere
				Reaktion på Nobelprisen i kemi
2011				Nanotech gør medicin grønnere
				Celler kan følges med ny nanometode
				Supermikroskop skal give os nøglen til flyvende tog og vidundermedicin
2009				Fantomsmarter under nanoteknologisk lup
World of Chemicals 2013	Chemistry driven global platform	1		Scientists transform plants into bio-factories to make drugs, compounds or ingredients

Social Media

Total exposure: 13 features have been exposed to a minimum of 22,250 viewers

Where	Media Type	Number	Readership	Story
Artikulation.dk 2012	Lecture consultancy blog	1		Speakerteknik I Topklasse: 6 Tedx-Pointer
Facebook Group 'Synbio World'	Synthetic Biology Community	1	42 members	TEDx CPH - Plant Power: The Ultimate Way to Go Green
Facebook Group 'Leukippos'	Synthetic Biology Community	1	507 members	TEDx CPH - Plant Power: The Ultimate Way to Go Green
Facebook Page 'Synthetic Biology'	Synthetic Biology Community	2	103,326 members	
2013				De Novo Biosynthesis of Vanillin in Fission Yeast and Baker's Yeast
2012				TEDx CPH - Plant Power: The Ultimate Way to Go Green
Facebook Group "Medical Museion"	Museum Community	1	2311 members	Numerous postings and activity on synthetic biology & biohacking.
Facebook Group 'iGEM Copenhagen 2013'	Synthetic biology students community	1	198 members	Students Behind Novel SynBio-Lightsource Students Behind Novel SynBio-Lightsource
Facebook Group 'WeCollaborate'	Knowledge Sharing Community	1	162 members	Viden I Netværk
Technos et Humain	French Technology blog	1		Adit Danmark : "Biologie Open Source, une collaboration inhabituelle
The Open Innovation Site Connect 2013	Web based Synthetic Biology Special Interest Group	1		Advance in re-engineering photosynthesis to make drugs, compounds or ingredients
The Original Going Solo Blog 2013	Compilation of blogs focused on informed, high quality, environmentally green content	1		Advance in re-engineering photosynthesis to make drugs, compounds or ingredients
The SynBiologist 2012	Global Online news service reporting most shared synbio stories from Twitter	1		TEDx CPH - Plant Power: The Ultimate Way to Go Green
Youtube 2012	International video sharing site	1	8704 views	TEDx CPH - Plant Power: The Ultimate Way to Go Green

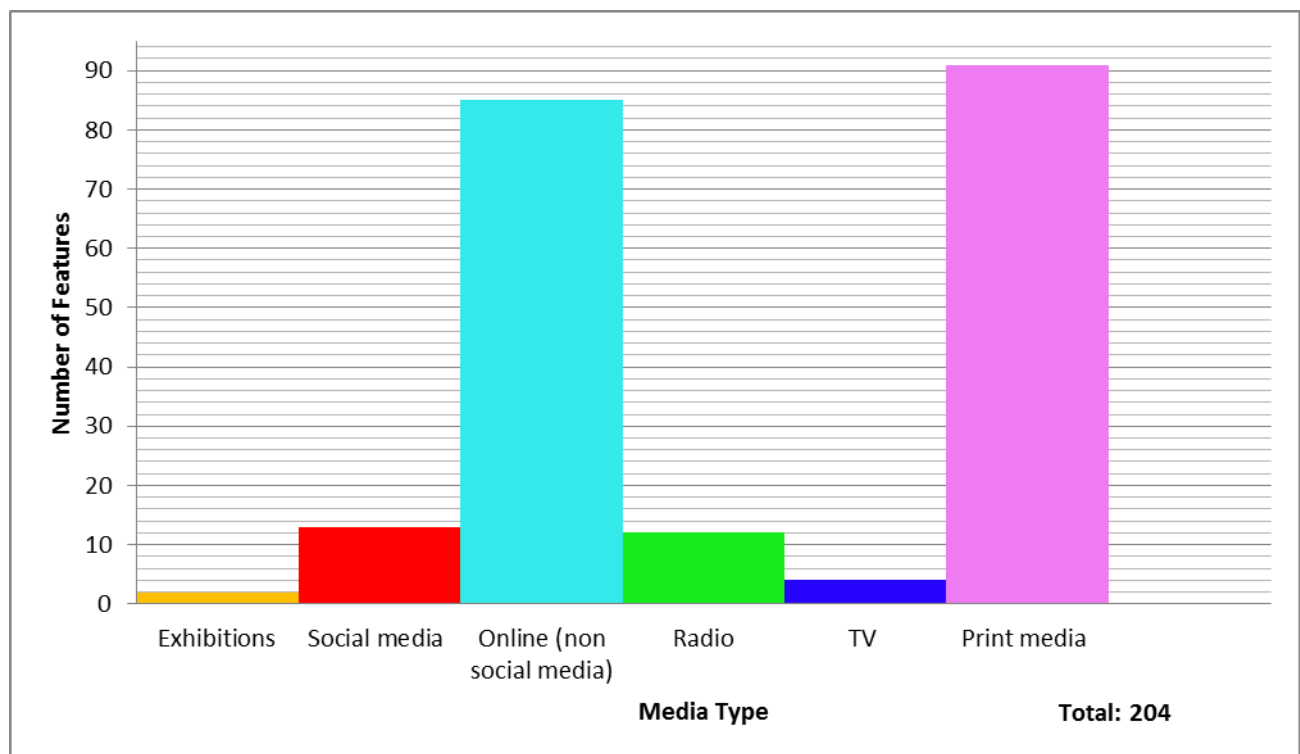
A Google search of Birger Lindberg Møller's TEDxCopenhagen talk 'Plant Power: The Ultimate Way to Go Green' gives 53.900 results.

A Google search of the ACS publication "Advance in re-engineering photosynthesis to make drugs, compounds or ingredients", gives 15.200 results.

Exhibitions

Total exposure: 2 features

Where	Event Type	Length	Exhibition Title	Visitors
Medicinsk Museion	Exhibition at Museum and research unit at the University of Copenhagen.	Jan 2013 – August 2014	Biohacking – do it yourself	
ESOF Science in the City	Science Festival	June 21 st - 26 th 2014	Breaking & Entering: how should science and society relate?	30.000 at ESOF



Internal Exposure

Center for Synthetic Biology scientists and science featured on the University of Copenhagen website (external and intranet)

Center for Synthetic Biology has been featured a total number of:

145 times in the internal media of UCPH.

72 of these have been featured in the internal newsletters of SCIENCE and Dept. of Plant and Environmental Sciences (PLEN) sent out directly via email to all employees of SCIENCE and PLEN since 2012 (when the newsletters were established)

Estimated readership of the PLEN and SCIENCE newsletters: 1.216 people

Number of people with access to PLEN and SCIENCE news on KUNet: 3.400

Estimated monthly readership of the University homepages:

University of Copenhagen: 217.950; PLEN: 29.199; Nano Science Center: 3.800;

Faculty of Health and Medical Sciences Homepage, Faculty of Science Homepage, Dept. of Neuroscience and Pharmacology, Niels Bohr Institute: not available

Total exposure: 145 features have been exposed to 254,675 readers

Where / When	Number of stories	Readership	Story
Front Page of University of Copenhagen Website	23	217,950 per month	
2014			Planteprofessor bliver ny leder af Carlsberg Laboratoriet
2013			Bevægeforstyrrelser hos unge kan linkes til ADHD
			Forskerne er ikke enige om, hvad ansvarlig forskning er
			Ny viden om hormonsystemet baner vej for bedre sygdomsbehandling
			Nedskæringer vil bremse internationalisering
			Kommunikationsforsker skal rådgive regering og Folketing om forskningspolitik
			Great potential for faster diagnoses with new method
			Chemistry magic promises better medicine with fewer side-effects
			Danish chemists in molecular chip breakthrough
			Chemistry breakthrough sheds new light on illness and health
			Researchers discover new explanation for diabetes and poor growth
			Stjerneprogram skal bekæmpe antibiotikaresistens
			Professor og biohackere indgår usædvanligt samarbejde
2012			New forage plant prepares farmers for climate changes
			Priser til hjerneforsker og immunolog
			Key to burning fat faster discovered
2011			Nano-tech makes medicine greener
2010			Copenhagen Plant Science Center
			Novo-bevilling styrker dansk plantebiotek
2009			Live recordings of cell communication
			Nanoresearchers challenge dogma in protein transportation in cells
			New insight in nerve cell communication
			Neuroforskere hjælper den stressede hjerne
Front page of Faculty of Health and Medical Sciences Website	4		
2014			Movement disorders in young people related to ADHD
2013			Biohacking: Do It Yourself!
			Researchers discover new explanation for diabetes and poor growth
2012			Dansk forsker førte an i et molekylært mesterstykke

Where / When	Number of stories	Readership	Story
Front Page of Faculty of Science Website (established 2012)	11		
2014			New knowledge of cannabis paves the way for drug development
			Nano technology reveals secrets of cancer molecule
			Groundbreaking insights in the hormone system pave the way for better medical care
			Plant Professor appointed new Head of Carlsberg Laboratory
2013			Great potential for faster diagnoses with new method
			Chemistry magic promises better medicine with fewer side-effects
			Chemistry textbook is a recipe collection for future pharma
			Danish chemists in molecular chip breakthrough
			Neutrons and X-rays - UCPH engagement in European Spallation Source, ESS
2012			Glowing DNA invention points towards high speed disease detection
			Prestigious EU grants awarded to 3 SCIENCE professors
Front Page Dept. of Plant and Environmental Sciences Website	6	29,199 per month	
2014			Plant Professor appointed new Head of Carlsberg Laboratory
2012			Pioneering Venture Into Producing Cancer Drugs in Solar Driven Bioreactors
			Prestigious EU Grant for Synbio Professor
			The UNIK Korean Connection
			EU grant PHOTO.COMM awarded to develop and exploit synthetic photobiological communities
			New forage plant prepares farmers for climate changes
Front Page of Dept. of Neuroscience and Pharmacology Website	4		
2012			Listen to Prof. Ulrik Gether on air at Danish radio P1
			Stor lægepris for forskning i hjernes signalsystemer til Prof. Ulrik Gether
			Søren G.F. Rasmussen månedens profil på SUND: Dansk forsker førte an i et molekylært mesterstykke
			Lundbeckfonden giver 34 mio. kr. til etablering af center for nanomedicin
Front Page of Nano Science Center Website	23	3.800 per month	
2014			New knowledge of cannabis paves the way for drug development
			Nano technology reveals secrets of cancer molecule
			Groundbreaking insights in the hormone system pave the way for better medical care
			New screening process of drugs will be cheaper, better and greener
			Better and cheaper nanomedicine on the way from new professor
			Danish chemists in molecular chip breakthrough
			Chemistry breakthrough sheds new light on illness and health
			Nano-research receives honors in China
2013			5.9 MDDK to research in fluorescent silver nanocluster technology

Where / When	Number of stories	Readership	Story
			Great potential for faster diagnoses with new method
			Danish chemists in molecular chip breakthrough
			Grants for research in bionanomedicines
2012			Glowing DNA invention points towards high speed disease detection
			Key to burning fat faster discovered
			Karen Martinez gets 12.3 MDKK allocated to the development of a new biochip platform
			Nano-tech makes medicine greener
			Professor Morten Meldal Chemistry receives U.S. award
			From science fiction to research breakthrough
			Morten Meldal is the new professor in nanochemistry
2010			Award for Dimitrios Stamou
			Grants for Prof. Karen Martinez and Prof. Bo Wegge Laursen
2009			New insight in nerve cell communication
			Nanoresearchers challenge dogma in protein transportation in cells
Front page of Niels Bohr Institute Website	3		
2013			Jesper Nygård: Nanoelectronics - from artificial atoms to the computers of the future - VIDEO
2012			Jesper Nygård new professor in nanophysics
2009			Lundbeckfonden giver 34 mio. kr. til etablering af center for nanomedicin
PLEN Newsletter and KUNet (established 2012) (internal) *	49	516 (PLEN newsletter) + 3,400 (SCIENCE employees with access to KUNet)	
2014			Planternes produktive potentiale - Børsen - 8 January 2014 (Nanna Heinz)
			bioSYNergy kickoff
			PhD defence for Tomas Laursen
			Synthetic Biology Workshop – collaboration across Øresund
			Michael B. Palmgren interview about use of GM-plants by Politiken. Jens Streibig in TV2 News. Animal Science in Berlingske
			Professor Birger Lindberg Møller appointed new Head of Carlsberg Laboratory
			Ny leder af Carlsberg Laboratoriet - Altinget - 27 February 2014 (Birger Lindberg Møller)
			PhD Defence: Selma Maric
			Beyond the PhD - research scientist at Novozymes Kenneth Jensen
			Course: Synthetic Biology in Photosynthetic Organisms
			PhD defense: Pernille Sølvhøj Roelsgaard
			PhD defence: Thiyagarajan Gnanasekaran
			What's hot in Plant Biochemistry
			PhD defense by Nethaji J Gallage
			PhD defence: Christian Berg Oehlenschläger
			PhD defence by Johan Andersen-Ranberg
			Ugens nørd om fremtidens fødevarer - TV2 Lorry - 4 June 2014 (Poul Erik Jensen)

Where / When	Number of stories	Readership	Story
			Science in the City
			Optimal Production of High Value Compounds – Dialogue Between Fields for more Efficient Output
			PhD defense by Pratik Shah
2013			Grant from the NOVO Nordisk Foundation
			What's hot in...Molecular Plant Biology
			Grants - June 2013
			PhD defence: Lisa Theorin
			PLEN professor appointed member of Australian Academy of Sciences
			PLEN in the media - March
			Symposium on synthetic biology and biohacking
			PhD defence: Towards Structural and Functional Analysis of the Plant Plasma Membrane Proton Pump – A Nanodisc Approach
			PLEN IN THE MEDIA 2013: Brug forskning til at skabe vækst – Berlingske – 13 March 2013 (Birger Lindberg Møller)
			PLEN in the media : The collaboration between biohacker space 'Biologi Garagen' and Center for Synthetic Biology is attracting media coverage
			Synthetic biology competition for students
			PLEN in the media – week 3-4: Planter kan lave brændstof og kræftmedicin – P1 Morgen – 22 January 2013 (Birger Lindberg Møller)
			UCPH 2016 Funds a great recognition of our research
			PLEN in the media - week 51 & 2: Danske forskere vil omdanne planters grønkorn til medicinfabrikker - Ingeniøren - 21 December 2012 (Poul Erik Jensen)
			Symposium on synthetic biology and biohacking
2012			Congratulations to Michael Palmgren, teacher of the year
			PLEN in the media: Tørke, Sojaboom og Sojakrig - Orientering, P1 - 27. july 2012 (Poul Erik Jensen)
			PLEN researcher is new Head of Studies for Biology-Biotechnology
			PLEN in the media: 3. Planet fra Solen uge 32 - Radio24syv - 11 August 2012 (Birger Lindberg Møller)
			PLEN in the media: Dansk syntesebiologi bygger bro til Kina - Ministeriet for Forskning, Innovation og Videregående Uddannelser – 4 December 2012 (Birger Lindberg Møller) and In a Research and Innovation supplement to Berlingske on 14 December, Center for Synthetic Biology was featured - read more on the Center website:Innovation Article Praises Synbio
			Center of Synthetic Biology Hosts Inaugural Master's Course in Synthetic Biology
			Danish synthetic biology at the forefront in China
			2012 Nobel Laureate Lecture: Professor Brian K. Kobilka, Stanford University
			PLEN professor receives ERC advanced grant
			Nobel Prize for Synbio Advisor
			Talk by PLEN professor at TEDxCopenhagen now online

Where / When	Number of stories	Readership	Story
			Seminar: Who is Responsible for the Social Responsibility?
			PLEN professor at TedXCopenhagen
			Grants for research projects
Science Newsletter and KUnet (established 2012)**	22	700 (recipients of SCIENCE newsletter) + 3,400 (SCIENCE employees with access to KUnet)	
2014			Two prestigious ERC grants to SCIENCE
			Plant Professor appointed new Head of Carlsberg Laboratory
			Nano technology reveals secrets of cancer molecule
			New knowledge of cannabis paves the way for drug development
2013			Seminar: Cytochrome P450: Nature's Versatile Catalyst
			Competition: Students! Apply for iGEM 2013
			Synbio Researcher Receives the Villum Young Investigator Grant of 5.9 mill DKK
			Exhibition on Biohacking Opening at Medical Museion
			Symposium on Synbio and Biohacking at Museion
			The results of the selection of projects for UCPH's 2016 Funds for interdisciplinary research
			2016 Funds: 18 projects receive funding
			Conference: Membranes and Membrane Proteins
			Newspaper: Synbio is Science Minister's Source of Innovation
2012			Danish synthetic biology at the forefront in China
			TedX Copenhagen talk by Professor Birger Lindberg Møller, Dept. Plant and Environmental Sciences
			Seminar by Iftach Yacoby
			Glowing DNA invention points towards high-speed detection
2012			Students Behind Novel SynBio-Lightsource
			UNIK evaluation: Unique interdisciplinary research
			Prestigious ERC grants to three SCIENCE professors
			University of Copenhagen's first course in synthetic biology is established and starts in February 2013
			2012 Nobel Laureate Lecture: Professor Brian K. Kobilka, Stanford University

