

Department of Science and Environment

Research strategy 2017-2020

Vision & Mission

Vision: To achieve scientific breakthroughs and contribute to solving the global societal grand challenges within science and the environment through interdisciplinary research, scientific curiosity, and creative collaboration with internal and external parties.

Mission: We:

- Promote interdisciplinary research projects within the department, within Roskilde University and with a regional and international outreach
- Develop the next generation of researchers in a team context
- Experiment with new ways of collaborating creatively with external parties in a truly integrative way
- Pursue curiosity-driven research in respect of its inherent importance, its importance to research based education and its importance related to feeding into applied and strategic research initiatives
- Communicate our results to enhance the impact of natural science at Roskilde University
- Involve students in research activities at all levels of their studies

The above-mentioned points of departure for our research ambitions and the strategic elements presented below, relate directly to key topics in *Strategy New RUC*: research with double impact, focus on research strengths, external funding, internationalization, and collaboration between the university, society and the business community. The research strategy and related action plans will integrate student recruitment activities wherever possible.

The Department's Research Profile

As a relatively small department within natural sciences, we are characterized by covering the breadth of the core scientific disciplines that our educational programmes rest upon, and at the same time we have built positions of international strength. These positions include green chemistry & enzymes, physics of soft & amorphous materials, biological production, environmental risk & ecotoxicology, biomedical research, proteins & peptides, cell biology and interdisciplinary mathematical modelling. We will continue this dual approach.

The department is organized into four sections: Chemistry, Environmental Dynamics, Physics & Mathematics, and Medical & Molecular Biology. The status and research plans for each section will be presented below, while interdisciplinary initiatives will be described under the *Strengthened Research Profile* heading.

Chemistry - Status

The current research profile of the chemistry section is based on Green Chemistry in environment and health, which entails the development of new sustainable approaches and technologies that can replace conventional chemical processes. Current examples include research projects on solar panels and CO₂-neutral biofuels, but Green Chemistry is obviously a broad area with contact points to essentially all fields of chemistry. In addition to external funding, success in this field promotes the societal impact of the group's work, both through the implementation of research results in environmentally friendly processes, and a broader dissemination to the public of the green aspects of chemistry.

Chemistry - Plans

The overall goal of the section is to retain the Green Chemistry theme as a main topic, and to promote the formation of research teams under this umbrella. The aim is to have three such teams, with significant external funding and 2-3 faculty members in each team. The teams will be formed within the chemistry section or through interdisciplinary collaboration with other department sections. The all-important challenge over the next few years for the chemistry group will be, under changed educational preferences and a significant generational change, to find a balance between breadth and specific research areas when hiring new faculty.

Environmental Dynamics - Status

The main research focus is on optimized and sustainable solutions to resource use and (associated) environmental risks of anthropogenic activities. This broad description includes three particular areas in which the section is internationally recognized: Biological Production covers development and support of innovative production of biological resources as a supplement to traditional agriculture, fisheries and petro-chemically based production. Environmental Risk covers research on fate and the effects of contaminants, and the research may feed into and improve concepts and procedures for ecological risk assessment, management and policy-making. Ecological Dynamics covers research from molecular to ecosystem-level, both in the environmental effects of multiple stressors, eutrophication and invasive species - all of these potentially augmented by climate change - as well as in the importance of specific habitats for biodiversity.

Environmental Dynamics - Plans

The strategy for future research has two stages. In the first stage, the aim is to further develop the success and solidify national and international recognition of the section's research within key topics, and to open up the three research areas to new interdisciplinary and creative collaborations. Key topics in Biological Production are molecular physiology of live-feed organisms, and up-scaling and industrial implementation of algae biomass production and live-feed based aquaculture. Key topics in Environmental Risk are fate and the effects of contaminants in sediment and soil systems, and the assessment and management of emerging pollutants, e.g. nanoparticles and microplastics. Key topics in Ecological Dynamics are the structure and functioning of coastal and benthic ecosystems, and interactions between kelp forest ecosystems and the global carbon cycle.

The second stage has a longer time perspective and requires interdisciplinary collaboration with other sections and departments, as well as the hiring of new staff to consolidate research teams. The ambition is to establish two centres (described below under the heading "Strengthened Research Profile") to host research areas, function as incubators for research and development, and to facilitate multi- and interdisciplinary approaches to problem solving.

Physics & Mathematics - Status

The research in Physics & Mathematics falls into three categories in which the group has established strong international recognition and which span the fields covered in the teaching programmes. Mathematical modelling, dynamics and its conceptual underpinnings: Traditionally, mathematical modelling at RUC has been an integrated part of physics. The research emphasis and present projects focus on mathematical modelling and dynamics related to viscous liquids, holomorphic dynamics, bio-chemical reactions, and biomedicine, including human health and disease modelling. Soft and Amorphous Materials: The long-term strategic focus on amorphous materials has matured into the research centre *Glass and Time*, with a unique focus on the close interaction between theory, mathematical/computational modelling and experiments.

Interdisciplinary capacity has been built up for the investigation of structural and dynamic properties of soft and amorphous materials using x-ray and neutron-scattering methods, both in-house and at large facilities. The centre has also attracted substantial external funding over the years. Reflections on and studies of mathematics and physics in societal, cultural, educational, and technical contexts: The research focus is on models and modelling in scientific and educational activities of mathematics and physics, on problem solving skills and the use of inquiry-based learning and ICT in mathematics and physics, and on the historical development of modelling in physics in the 20th century.

Physics & Mathematics - Plans

The research in mathematics and integrated mathematical modelling will be further strengthened to also benefit the subject-integrated master education and student involvement in research. The research related to the educational, historical and philosophical aspects of the subjects will be consolidated and directed towards including the subject-integrated education programmes. The *Glass and Time* centre will be further strengthened with a broad spectrum of research activities, including curiosity-driven research. The team and the experimental activities in soft and amorphous materials will be intensified with new recruitments. New opportunities in Materials Science are also opening up with the globally-leading facilities European Spallation Source and MAX IV (X-ray) in Lund. The section will head the RUC high-performance computing centre.

Medical & Molecular Biology - Status

The research group conducts research into basic and translational science of molecular biology and biomedical problems, often in collaboration with external partners from the private sector or public institutions. Common to the group's activities is an interest in cellular signalling pathways affecting cell appearance, metabolism and behaviour. The group works with bacteria, yeast, insect and mammalian cells as model systems and therefore covers a broad spectrum of biological disciplines.

The group has had a long-term collaboration with Region Zealand's hospitals, both scientifically and educationally in terms of the Medical Biology programme. The last three years the group has also been an active partner in the RUC/Region Zealand Coordinating Committee, along with other RUC researchers from Health Promotion, Healthcare IT and Organization of Health.

Medical & Molecular Biology - Plans

The section wants to continue to be competitive and develop collaborations with external partners in both basic and translational research. The existing collaboration within the Region Zealand framework is also expected to lead to closer research collaboration, in a new framework, with research-active lecturers at the Biomedical Laboratory Scientist education.

Key areas that we want to develop further are biomedical research (biology of cancer, pathogens, autoimmunity and life-style diseases), protein and peptide research (development and use of bioactive peptides and antifreeze proteins), and cell biology research (molecular mechanisms in DNA replication, gene regulation and signalling). Interdisciplinary collaboration with chemistry and mathematical modelling will be intensified and supported by new recruitments.

Student involvement in research

We will offer students on the bachelor modules to be affiliated with a research group, which will include attending research seminars and other research related activities. This initiative is to be used in recruitment and retention activities.

Research Quality

Overall Objective

In general, research quality as measured by publications and external funding has been quite successful over time for a relatively small department with a broad profile in natural sciences. Emphasis will continue to be focused on publication in international peer-reviewed scientific journals, and the RUC publication strategy is currently being implemented regarding hard scientific impact measures. However, the department also recognizes a considerable, and as of yet under-exploited potential within societal impact, especially on environmental/green chemistry and health/medical themes.

We will work on increasing societal impact by generating knowledge and technical development as an integrated part of society and by supporting international networks and increased regional collaboration. We will work with new ways of collaboration and with the formation of centre structures with NGOs, private companies, including start-ups within medico, bio and environment, public authorities, and hospitals (primarily in the Zealand region) in order to obtain an improved 'double impact'. See *Strengthened Research profile* for suggested centres.

We have limited opportunities for access to large and/or expensive equipment, which poses a particular challenge to research quality for the experimental sections. Resources in this area are essential to form an attractive environment for students and international peers and for our ability to compete scientifically and in calls for external funding.

Goals/Milestones

We will form research teams within each section to secure a strategic focus and critical mass, and we will work on developing research teams (possibly temporary) across the sections and with research teams from other departments in order to be able to address new research agendas. Internally, it is important to increase collaboration between the three areas of a) environmental dynamics and medical & molecular biology, b) mathematics & physics, and c) chemistry, where we have already identified specific potential.

We will introduce prestigious international "Sømine Research Summits", where internationally recognized researchers will be invited to advance the scientific frontiers. We place great emphasis on heavily involving PhD students in these summits, as we consider PhD students to be an integral and inspirational part of our research. Students will also be involved in such summits. We will explore the possibilities for launching a sabbatical/mini-sabbatical programme for faculty members to support continued international inspiration, network development and talent enhancement.

Similarly, "Industry Summits" at RUC Campus will be developed to invite companies to briefings on the research activities at RUC and to discuss further and future collaboration. We will introduce research-based collaboration with start-up companies to inspire faculty and students to foster spin-outs. The goal is that the basis for one spin-out is created by faculty and/or students within the strategy period.

At least two regional research collaboration agreements will be made with professional, bachelor education programmes to include research-active lecturers at the relevant educational institutions. This is of special relevance to Medical & Molecular Biology and Environmental Dynamics.

Large instruments that are of broad interest at the department will be identified and a plan for investment will be developed in combination with a plan for exploiting international facilities.

Strengthened Research Funding

Overall Objective

Over the years, the department has been successful in obtaining externally funded projects. The grants are obtained from large funds for basic science (Danish National Research Foundation), the research councils, Innovation Fund Denmark, and more dedicated application oriented funds like Velux-Villum and Nordforsk. During the autumn of 2016, researchers at the department have submitted applications for a little over DKK 140 million and the grant revenue in 2016 was almost DKK 18 million.

The department wishes to increase the level of external funding by engaging in initiatives that will increase the success rate and by having a strategic focus on EU and international funds.

Goals / Milestones

- Improve applications from individual researchers through collegial support, discussions and development of an internal peer review processes (no later than June 2017) to be aligned with the peer review process at RUC level.
- Increase the number of funding applications to the EU. Utilize international networks of senior staff to increase the number of international applications with special focus on the EU, including bio-economy.
- Increase the number of applications for international funds other than the EU.
- Enhance the focus on funding for applied and/or interdisciplinary research.
- Increase industrial PhD funding.

Strengthened Research Profile

Overall Objective

We want to be known as a department that has a strong research base in core disciplines within natural sciences and the ability to put these competencies and strengths into play in innovative ways and contexts when generating new knowledge that is relevant for our future society. Hence, we will prioritize the establishment of interdisciplinary centres to contribute to research into major, complex grand solutions and to increase Roskilde University's focus on double impact. This is a significant strategic element, and the department will support interdisciplinary initiatives guided on a "will to succeed" principle. The department's input for Forsk2025 and the European Spallation Source strategy provide excellent descriptions of selected initiatives. A specific focus is to succeed with centres for Circular Economy and Health involving all RUC departments. In the next section, we will elaborate in more detail on specific suggestions for interdisciplinary initiatives.

Communicating our research is a central prerequisite for enhancing impact, and at the same time, it is important for strengthening the recruitment of students for our educational programmes. A proactive research communication plan will be developed before summer 2017.

Strategic development of the research profile and research quality go hand in hand with faculty recruitment and retention, and with talent development. The recently approved plan for professor positions, which is now under implementation, is a crucial starting point for the identification of new research focus areas and research talents forming and leading new teams. In parallel, we will work on a plan for the development and support of postdocs/assistant professors. There will be particular focus on strengthening and utilizing international networks for this group.

To support the interdisciplinary research, we will implement a hiring strategy that focuses on collaboration across scientific disciplines.

Interdisciplinary research initiatives

Based on the solid professional research conducted within the sections of the department, new endeavours will be sought in truly interdisciplinary research collaboration projects. Here we present suggestions for interdisciplinary initiatives - some of which might be part of overall RUC initiatives. Most of the centres will have the greatest potential to succeed if they are based on collaboration with RUC researchers from technology, humanities and social science.

Quantitative and Mathematical Biology

Modelling and computer calculations of biomedical systems make it possible to understand how complex human diseases arise and develop, and how they can be diagnosed and treated. Mathematical modelling and computer calculations are key tools to identify and test new active ingredients or treatment principles in the pharmaceutical and biomedical industry. The understanding of the combinatorial biological effect of bioactive substances, e.g. in drug development or in the diet, also requires a need for new mathematical modelling methods. The research initiative will support the planned new masters' programme in medical/bio-mathematics.

Green Chemistry

Within the framework of Green Chemistry, collaboration will be enhanced across sections in the department as well as with research groups in other departments at RUC. Green Chemistry was a major participant in a previous, highly ambitious, inter-departmental application. These contacts and collaborations should be revitalized in this initiative.

European Spallation Source and MAX IV

The goal is to be a visible and active participant in the Danish national activities related to European Spallation Source and MAX IV in Lund, Sweden. The Physics section at the department hosts world-class niche research using scattering methods, both in viscous liquids and in soft materials, and the aim is to create a scattering community across the department with chemistry and biology sections, also including the strong computational capacity.

Gut Ecology and Metabolism

The ambition of the centre is to create an interdisciplinary research environment that brings together different disciplines within molecular biology, physiology, biomedicine, microbiology, environmental biology, mathematics and chemistry with the aim to investigate the interaction between metabolism and bacteria-host interactions in the intestinal tract. This is relevant for diseases like cancer, inflammation, diabetes, obesity, and psychiatric conditions.

Biological Production: Copepod Molecular Physiology, Aquaponics, and Breeding of Ornamental Fish

Establishment of a centre to facilitate and support different applications of biological production, including a core facility consisting of the International Copepod Reference Centre, and a dynamic research incubator for novel and innovative initiatives within aquaculture application.

Centre for Interdisciplinary Research in Environmental Risk and Sustainability

The aim of this centre is to bring together different disciplines to address key environmental challenges related to natural hazards, anthropogenic and societal issues at different temporal and spatial scales.

BioFabLab

We intend to establish a BioFabLab in order to enhance student-driven research and to mediate new collaborations with scientists from other disciplines within the department and between RUC departments. The purpose is to establish a facility that is available to students and researchers from RUC or outside, who have "a bright idea" in the biological/technical area that they would like to test. The BioFabLab will support RUC projects with equipment and experiments built and designed by the students themselves. It is a novel concept that will function as an incubator for developing and testing new interdisciplinary ideas. The establishment of such a laboratory will build on experience made by the current FabLab, and will greatly expand the opportunities for the most creative RUC students to test their own research ideas with access to expertise in biology, technology and electronics.

Goals/Milestones

We want to establish at least two research centres before 2020. National or international funding on a level of at least DKK 10 million should be raised in total for the centres.

We aim at establishing a BioFabLab, at least in a minimum viable form, before the end of 2017.

PhD Education

Overall Objective

PhD students are the cornerstone of external collaborations and they provide a substantial amount of project supervision to pre-graduate students. They also contribute importantly to the creation of a vibrant and innovative research environment and they often constitute important links between research and industry. It is therefore important for the research teams to increase the number of PhD students and to integrate PhD students as peers in the research teams.

The strategy is to continue to establish co-financed PhD projects with external partners, supplemented by the department prioritizing fully financed PhDs to support new research group leaders and creative interdisciplinary initiatives that may otherwise have difficulty obtaining external funding for scholarships. RUC's current focus on an average of 50% co-financing will be maintained and it should be considered whether it is possible to guarantee 50% co-financing to be attractive to external parties.

Internationalization is a cornerstone of PhD training. One of the department's future focus points, therefore, will be to ensure that extended international research visits are an integral part of all PhD projects.

Goals/Milestones

The PhD students must be prepared for research-based teaching according to the RUC model.

The buddy concept for PhD students will be revitalized.

At present, the department offers three PhD courses and contributes to a few other courses. A specific part of all PhD courses offered will be to introduce the PhD students to an international network.