



Life Science

UiO • University of Oslo



UiO strategy for the life sciences



Preface

Background

On 1 February 2012 (2013/1775), the rectorate of the University of Oslo (UiO) commissioned Molecular Life Science (MLS^{UiO}) to prepare a proposed strategy for the life sciences for adoption by the University Board. The work was to be coordinated with the planning process for a new research and teaching facility for the life sciences, chemistry and pharmacy. At the same time, a communication strategy was commissioned based on the life sciences strategy, with the objective of powering the adoption and funding of the building project.

Mandate for the strategy work

The mandate for the strategy work states as follows:

The strategy for the life sciences will enable UiO to develop the aim expressed in Strategy 2020 and the strategic elements contained in the QA1 document regarding new facilities for life sciences, chemistry and pharmacy. On this basis, together with key partners UiO will secure Norway international competitiveness in the life sciences, thus making a significant contribution to solving the great global challenges in health, environment, climate and energy. Key words for the strategy are professional excellence, innovative interdisciplinarity and convergence, attractive educational opportunities, state-of-the-art infrastructure, good career paths, innovation and societal relevance, collaboration, synergies/work-sharing and concentration.

UiO's relationship with Oslo University Hospital (OUS) is of central importance in this process. Together with OUS, the University of Oslo can develop an integrated life sciences hub with competencies and resources ranging from basic science and mathematics to medicine and health sciences, including relevant areas of the social sciences and humanities. Moreover, it is vital that the strategy sheds light on synergies, work-sharing and collaboration with other key research and education actors regionally and nationally.

A proposed strategy for the life sciences at UiO shall be prepared, which will:

1. provide a general description of the current situation in the life sciences at UiO, including opportunities and challenges, seen in a regional, national and international perspective
2. lead to an overarching vision, goal and roadmap
3. facilitate the mobilization of UiO's resources broadly and in keeping with the convergence concept described in the QA1 needs analysis, and prepare for full, immediate use of a new building for the life sciences, including chemistry and pharmacy
4. strengthen the collaborative axes between UiO and OUS, and between UiO/OUS and relevant business development actors
5. explain synergies and collaboration with other central research and educational institutions.

The work

A writing group with the following members was established:

Odd Stokke Gabrielsen (Chair, Head of MLS)
Knut Fægri (Professor, the Faculty of Mathematics and Natural Sciences (MN), Department of Chemistry (KI))
Inger Sandlie (Professor, MN, Department of Biosciences (IBV))
Ole Sejersted (Professor, the Faculty of Medicine (MED), Institute of Basic Medical Sciences (IMB))
Øyvind Fensgård (Advisor, MLS)
Guri D. Aarnes (Head of Section, Office for International Relations and Research Support)
Vibeke Alm (Senior Advisor, Office for International Relations and Research Support)

The writing group held six meetings (7 & 20 February, 6 March, 30 April, 15 May, 2013) and a one-day seminar (18 April 2013). Olav Gjelsvik (Head of the Centre for the Study of Mind in Nature) also took part in the one-day seminar. The core group arranged two workshops on 9 and 10 April, 2013, attended by 30 representatives from biomedicine, chemistry/physics/pharmacy, environment/biology, mathematics/informatics, humanities/social sciences, deans of research and the Communication Group. Key representatives of close partners such as Oslo University Hospital (OUS), the South-Eastern Norway Regional Health Authority (HSØ), the Norwegian School of Veterinary Science (NVH) and Norwegian University of Life Sciences (UMB) were also invited.

The strategy has been sent on a round of consultations prior to ordinary processing.

UiO strategy for the life sciences

The 21st century is frequently described as “The century of the Life Sciences”,¹ based on the knowledge revolution that provides us with a completely new understanding of life and life processes. This paves the way for better health, sustainable environmental measures and a growing green bioeconomy. UiO’s vision is to be an important actor nationally and globally in this development, by delivering high quality and high value research, by educating candidates with expertise and talent, and by contributing to innovation in health and the environment for the benefit of society. In order to succeed, UiO must develop “convergence” – closer interaction between a diversity of research environments and disciplines – to ensure quality and relevance.

Introduction

In March 2000, President Bill Clinton and Prime Minister Tony Blair declared in a joint statement that: “The effort to decipher the human genome ... will be the scientific breakthrough of the century – perhaps of all time.” This marked the symbolic starting point of a new era in which the life sciences are expected to affect our lives to an ever growing extent. This development has taken place over a considerable period of time. The history of the Nobel Prize awards shows that since 1953, when Watson and Crick revealed the structure of the DNA molecule, a total of 72 prizes in either chemistry or medicine have been awarded for new molecular understanding of life processes. Molecular biology originated from this research, and has linked chemistry, biology and medicine through a deep common understanding of the basis of life processes.

What are the life sciences?

Life sciences embrace a wide range of disciplines, because life itself is complex, with multiple facets and relationships. Since a strategy for the life sciences at UiO cannot cover the entire field, we must delimit it.

In our strategy we define the life sciences as including all scientific disciplines studying the composition, structure and functions of living organisms. Medicine and biology constitute the core, backed by chemistry, physics and mathematical subjects. This strategy also includes the social sciences and humanities when these examine causal relationships between behaviour or consciousness and the biological foundation, or analyse challenges arising in the encounter between the application of the life sciences and society’s values and priorities.

Note that the core subjects of biology and medicine are broadly interpreted such that biology includes disciplines such as molecular biology, microbiology, evolution and ecology etc., while medicine covers all human biology with related disciplines such as odontology, psychology, pharmacy and the like.

Facts about the life sciences at the University of Oslo (UiO)

UiO ...

- has > 27 000 students and 6000 employees
- is Norway’s largest research community in the life sciences, and together with Oslo University Hospital (OUS) and Akershus University Hospital (Ahus) constitutes a life sciences powerhouse in Norway
- publishes >1500 articles in the life sciences annually
- has increased the volume of publications by 73% since 2003
- has >2000 research fellows in the life sciences
- hosts four Centres of Excellence in the life sciences (CEES, CCB, CIR, and NORMENT), three of which cooperate with OUS
- has two centres – BiO and NCMM – which have no faculty affiliation
- has three national infrastructure platforms in sequencing, imaging and biosystematics (NSC, NorMic, NCB)
- has six K.G. Jebsen centres in collaboration with OUS and Ahus



Today the life sciences have an enormous field of application. DNA analyses have become common and represent powerful evidence in court cases. Aquaculture is among Norway's prime sources of revenue. Food security and production are gaining new analytical instruments and tools. Synthetic bacteria can create designer products, from drugs to biodiesel.² DNA-based diagnostics are becoming increasingly precise, not least in the early detection of cancer. A range of effective new drugs developed with the input of the life sciences will soon become available. Gene signatures will give an accurate basis for personalized therapy and preventive health interventions. New expertise on ageing and mental health can improve many people's lives. Politicians must continually discuss the ethical choices which new possibilities confront us with. Climate impacts demand an understanding of ecology and interaction. Green industry must be based on life sciences. Both the OECD³ and the US government⁴ expect the bioeconomy to grow and become an important part of the international economy. Many sectors are affected by the life sciences. So far we have only seen the start of "The century of the Life Sciences". Illustration photos from colourbox.com.

Global challenges

Global challenges in our era are many and demanding – global warming, unequal access to energy, water and food, an ageing population, poor health and pandemics. The EU's 2009 Lund Declaration affirms that research must focus on "The Grand Challenges."⁵ Similar recommendations are found in reports from the OECD,³ EU,⁶ National Academy of Sciences,⁷ and the Massachusetts Institute of Technology.⁸ The Norwegian government's recent white paper on research⁹ adopted a corresponding perspective. If research is to contribute more effectively to solving such complex problems, we

must remove the rigid thematic approaches that restrict solutions. Other approaches recommended include renewal through enhanced state-of-the art research initiated by the research community itself, global leadership, further development of enabling technologies, excellence and good networks for communication among knowledge institutions, as well as infrastructure for world-leading research. As many global challenges clearly have a biological aspect, the life sciences are expected to play a key role in the future.

Here we provide some examples of the exciting research into the life sciences that is taking place at UiO:

- An epigenetic test which can predict colorectal cancer long before it becomes terminal has been developed at CCB.¹⁰ This is a promising advance since in Norway approximately 3000 people annually are affected by the disease.
- Water channels that drain waste from the brain have been discovered at CMBN¹¹ and NCMM¹² – a discovery that may be of significance for research into Alzheimer's disease.
- The basic cause of gluten intolerance (coeliac disease) has been revealed at CIR.¹³ This is an example of how the life sciences can give many people hope of a future with fewer health problems.
- All the genes of the cod and an unexpected immune system have been brought to light at CEES,¹⁴ findings that provide hope of a healthy and robust new aquaculture industry.
- Researchers at NHM¹⁵ are involved in developing gene-based biological barcodes in a new interpretation of Linnaean taxonomic system, whose uses include detecting the presence of foreign proteins in food, for example horsemeat in lasagne.
- A correlation between self-control in children and the size of the *anterior cingulate cortex* has been identified at the Department of Psychology – an example of the life sciences interfacing with psychology.
- Researchers at CSMN¹⁶ are studying the philosophical implications of systems biology and contributing an important perspective on the life sciences.

This brief selection of examples fully shows that the life sciences affect large parts of UiO and their scope clearly reaches beyond medicine and biology.

The life sciences in Norwegian society

As indicated by the government's white paper on future perspectives,¹⁷ the main challenges for Norwegian society in the future are the decline in demand in the petroleum industry, an ageing population and considerable climate and environmental challenges. To meet these challenges, the contributions of life sciences research are essential. In many respects, technological development and innovation will be of decisive importance for sustainable solutions. The government wishes to prioritize multisectoral technologies such as biotechnology¹⁸ to pave the way for innovation in industry and the private sector. In connection with this, the government has adopted a new "National Strategy for Biotechnology 2011–2020."¹⁹ The field of application is wide-ranging and the strategy designates four thematic focus areas:

- Aquaculture, seafood and management of the marine environment
- Land-based food and biomass production
- Environment-friendly industrial processes and products
- Health, health services and health-related industries

To follow up this strategy, substantial government funding has been granted for biotechnology. Norway has a strong knowledge base and altogether 14 of 34 Centres of Excellence conduct research on the life sciences. Nationally we can observe an evolving biotechnology industry. UiO's Strategy 2020 highlights the life sciences as an interdisciplinary priority area which also includes a new research and new premises for research and education in life sciences, chemistry and pharmacy.

Targeted education is important. The challenges we face demand new and different types of knowledge, as well as the ability to adapt and originality/innovation. The most recent white paper on research indicates that sound educational quality and the right skills will be more clearly integrated in research policy⁹ than has previously been the case. The life sciences have great potential to fulfil the objectives, and this can also increase much-needed recruitment to science and technology subjects.

The life sciences at UiO

The life sciences embrace an extremely wide spectrum of UiO's activities including many scientifically strong environments. The Faculty of Medicine (MED) occupies a central position and its three large departments cover three important axes in education and research: basic biomedical research, clinical research and health research in relation to society. The faculty hosts the following centres of excellence: CIR,¹³ CCB,¹⁰ and NORMENT,²⁰ as well as the former CMBN,¹² all of which have an interfaculty element. The Faculty of Mathematics and Natural Sciences (MN) also has a number of strong environments with a variety of roles in the life sciences, including one centre of excellence: CEES.¹⁴ The new large Department of Biosciences focuses on biology from the basic molecular level to large ecosystems. Pharmacy plays a key role in building bridges from chemistry and biology to the application of drugs. The Department of Informatics is expanding its activities in the direction of bioinformatics. Basic sciences such as chemistry, physics and mathematics are increasingly turning towards the life sciences, and have several strong environments that will significantly influence the direction of life sciences research and teaching at the faculty. The Faculty of Dentistry (OD) builds its professional activities on a natural science knowledge base and offers innovative activities, for example in the interface between material science and nanotechnology. These three faculties are responsible for the interfaculty initiative Molecular Life Science (MLS^{UiO}), which has line responsibility for the two centres – the Biotechnology Centre of Oslo (BiO),²¹ and the Norwegian Centre for Molecular Medicine (NCMM),¹²

the latter in close cooperation with the South-Eastern Norway Regional Health Authority (HSØ). The life sciences can also draw on several other strong research environments at UiO. The Faculty of Social Sciences (SV) has strong research environments at the Department of Psychology in cognitive neuroscience, integrated cognitive-neurobiological ageing research, and neuropsychology related to severe mental disorders. The faculty's Centre for Technology, Innovation and Culture (TIK) hosts projects directly targeting innovation from the life sciences. The centres of excellence at the Faculty of Humanities (HF) – MultiLing²² and CSMN¹⁶ – have cutting-edge expertise in cognitive science research, and CSMN also in ethics. Other leading environments at these and other faculties will also contribute significantly to the life sciences at UiO. In particular, the Faculties of Humanities and Social Sciences (HumSam) will provide key input in finding solutions to major societal challenges.

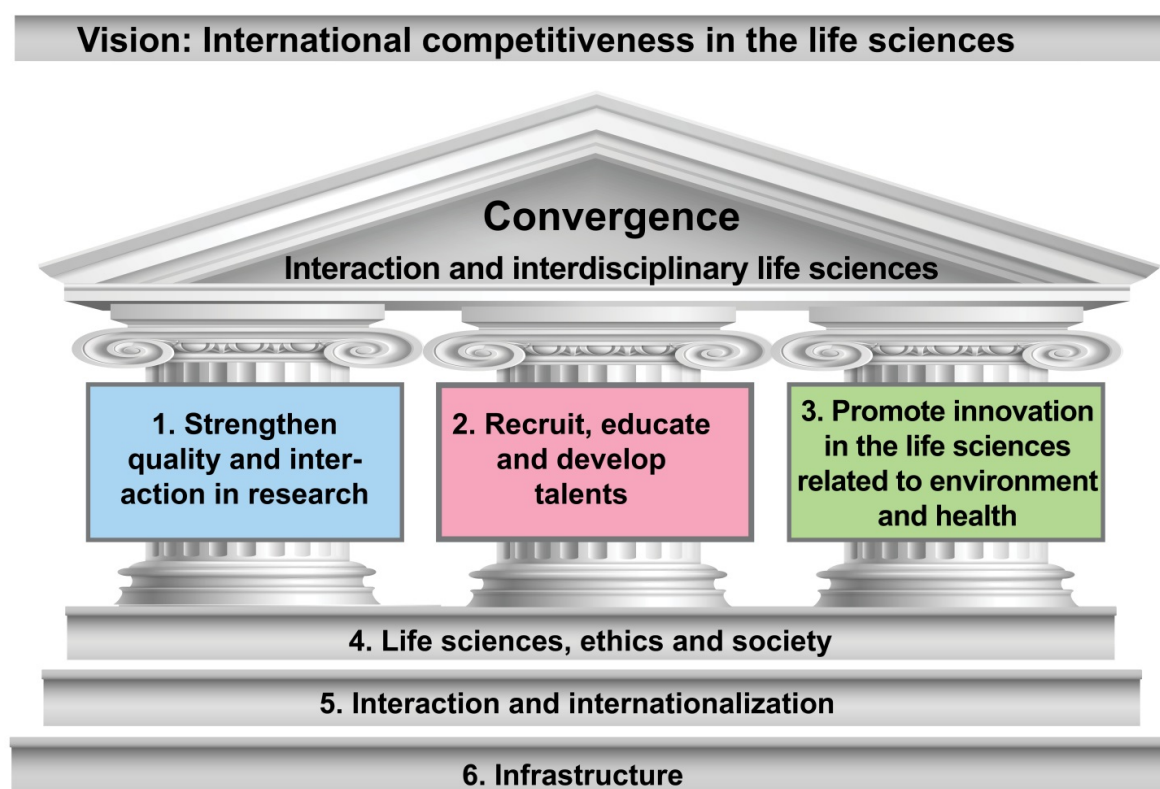
UiO's close partners are of decisive importance for the University's competitiveness. UiO is reliant on Oslo University Hospital (OUS) to succeed in its investment in the life sciences in the field of health. Here closeness and complementary skills are the key for research, education, innovation and infrastructure. However, both Akershus University Hospital (Ahus) and the Norwegian Institute of Public Health play central roles in this close interaction. Our nearest neighbouring university, the Norwegian University of Life Sciences (NMBU) at Ås represents an important axis of partners in life sciences related to the environment and food production. Here also complementarity and proximity are key factors.

Vision and overview

The aim of this strategy is to fulfil UiO's fundamental vision for the life sciences as formulated in Strategy 2020, and to **secure and strengthen international competitiveness in the life sciences**. The objective is for UiO to become an important actor in developments in the life sciences, with a special responsibility nationally, and visibility and relevance globally. UiO wishes to achieve this by delivering research of high quality and value, through educating candidates with expertise and

talent, and by promoting innovation in environment and health for the good of society. UiO wishes to draw on the University's entire spectrum of relevant research environments in line with the extended definition of the life sciences. UiO will participate actively in regional, national and international collaboration. To succeed in meeting these international challenges, UiO must further develop "convergence" – closer interaction between different research environments and disciplines.

The disposition and thematic breakdown are described below and explained in the text of the diagram.



Since the life sciences have a broad impact on society and embrace large parts of UiO, the strategy covers a number of topics. This applies to different disciplines, research and education, spanning infrastructure to ethics. The topics are organized as illustrated in the diagram. "Convergence" is chosen as the overarching perspective, the "roof" over the whole structure. The three "pillars" show how this perspective will pervade research (1), education (2) and innovation (3). Three interdisciplinary topics in particular that affect research, education and innovation are presented. These are ethics and society (4), in which links to the humanities and social sciences are specifically described; international and national collaboration (5), focusing on ambitions for interaction with other actors; and infrastructure (6) in which key framework conditions are discussed. As a whole this "structure" reflects how UiO will become a leading university for the life sciences in a broad sense.

Overarching perspective – convergence and interdisciplinarity

The life sciences are particularly suited to realizing UiO's central strategic objective: "The strength represented by the academic breadth of the university will be utilized even better through interdisciplinary research and education." The life sciences encompass large parts of UiO, and subject development across organizational boundaries is occurring more frequently. No unit, department or institution "owns" this subject area – the life sciences flourish in interfaces, and it is precisely here that we often find cutting-edge research.

We have therefore chosen the term "**convergence**" as an umbrella term for the strategy. Convergence in research and education entails a ground-breaking integration through extensive collaboration among researchers from different disciplines with the aim of creating new areas of knowledge, new applications and opportunities. Convergence reflects a dynamic, cross-cutting mindset that appears in several strategies adopted by leading American,^{8,23} European,^{24, 25} and Nordic universities.²⁶ The term "convergence" is derived from a recent strategy report from the prestigious Massachusetts Institute of Technology (MIT) in the USA, which uses the term to highlight the importance of closer links between the life sciences and other science disciplines such as chemistry, physics, mathematics, informatics and engineering.⁸ MIT views the interdisciplinary approach as a key prerequisite in exploring complex research issues: "Convergence is a new paradigm that can yield critical advances in a broad array of sectors, from health care to energy, food, climate, and water." The concept of convergence is presented as "the third revolution" following the growth of molecular biology (first revolution) and the breakthrough of genomics (second revolution).⁸

Interdisciplinarity occupies a central position in many important scientific breakthroughs and acts as a key to "highly creative research".²⁷ Sometimes this is the source of new integrated interdisciplinary research areas that receive separate designations. Bioinformatics, computational biology and systems biology, synthetic biology, biomaterials and nanobiology are some examples of such fundamental convergence. The choice of the term "convergence" in this strategy underlines the need for a development in which interdisciplinarity is perceived as more comprehensive and integrated than is the case in a single project with contributions from various disciplines.

Cross-cutting research challenges the classical division of research according to discipline. Convergence must be based on strong disciplines rather than replacing them. Basic subjects such as chemistry, pharmacy, physics, mathematics, biology and medicine must continue to be strong knowledge bases, while fruitful, cross-cutting thematic combinations evolve at the same time. The

strategy must facilitate the production of a research culture and educational pathway underpinned by a strong subject specialization while developing the ability of researchers to collaborate with other disciplines on joint research issues. This is a strategy which will broaden the concept of convergence to embrace parts of the social sciences and humanities, resulting in better interaction between natural sciences and social sciences/humanities.

In the study of nature, focus is often placed on different (vertical) levels: at the base a level of molecules and living cells, and higher up organisms that are part of the interaction that creates environments and ecosystems forming the biosphere as a whole. Integrating knowledge at one level with knowledge at a higher level poses a challenge that requires so-called vertical convergence. Systems biology and integrative biology represent one such approach in biology, and the link between genotype and phenotype in ecology and evolution is another example. Psychology and language can also be fitted in along this vertical axis, as well as all social science subjects devoted to human behaviour in relation to a biological foundation. On the other hand, when we look for greater interplay between the life sciences and basic scientific subjects such as chemistry, physics and mathematics, this interaction occurs more between different disciplines on the same "level", which are however based on different approaches and evidence bases. The challenge pointed out in the MIT report could therefore be termed horizontal convergence. Both aspects are regarded as vital in our strategy.

With its broad portfolio of subjects and close partners in the region, the University of Oslo occupies a unique position in Norway to develop convergence between many different disciplines and along many axes. By exploiting combinations of subjects and investigating points of intersection between different disciplines, UiO can take advantage of its breadth to increase its academic strength. This is an extremely promising scenario for the life sciences in which subject development is such that convergence is a natural path to follow moving forward. Together with other research institutions such as OUS, Ahus and NMBU, the University of Oslo will develop a "comprehensive Life Science cluster" in the region. However, UiO's position also entails a specific national responsibility. UiO will be an active partner in collaboration and an engine driving forward this important area nationally. UiO's investment in the life sciences must lead to advances far beyond the Oslo region.

*The life sciences of the future
require convergence.*

Pillars in the strategy

– quality and interaction – students and talents – innovation

1. First pillar: Strengthen quality and interaction in research

Quality is a mandatory requirement for successful research. The purpose of attempting to integrate convergence in our ambitions for research is to strengthen quality, competitiveness and relevance.

Specific strategic goals for research

Outstanding research in the life sciences demands ...

- **interaction and synergy**
 - **between academically strong environments,**
 - **between environments with a variety of cutting-edge expertise across disciplinary borders, and**
 - **openness to interplay between research environments at different organizational levels**
- **good strategic coordination of recruitment, laboratories and other infrastructure**
- **competitive subject development in areas in which the pace of discoveries is particularly high**

Implementation

UiO will...

- remove formal barriers and administrative structures which create unnecessary difficulties in conducting interdisciplinary life sciences research across units at UiO and vis-à-vis our partners
- strengthen strategic interaction between academic leadership and the committee for infrastructure to help to ensure that allocations made by them reinforce the life sciences strategy
- develop MLS^{UiO} as a cross-faculty strategic research instrument to bolster a stronger convergence culture within life sciences research
- earmark internal strategic funding for several cross-cutting projects that promote convergence
- earmark internal strategic funding for the life sciences such that this enhances the likelihood of obtaining external funding
- reinforce computational life science across institutions and through regional, national and international collaboration
- promote international researcher mobility by both encouraging our researchers to travel to other countries, and facilitating visits to UiO from guest professors and senior researchers worldwide

- strengthen research collaboration with relevant business sectors

Background

Status. UiO hosts Norway's largest research environment in the life sciences and together with the university hospitals in the region represents the main hub for the life sciences in the country. Research production has increased by an impressive 73% over the last decade. In connection with the Research Council of Norway's evaluation of biology, medicine and health sciences in Norway, the Nordic Institute for Studies in Innovation, Research and Education (NIFU) conducted an analysis of publications and citations (March 2011).²⁸ The findings show that publications from the Oslo region are increasingly cited.²⁹ No other institution has, or has had, as many centres of excellence in the life sciences and K.G. Jebsen centres as UiO (see box on page 3). Allocations to national research infrastructure platforms are also important. Several of the centres collaborate with the university hospitals. UiO is thus well positioned to succeed together with its partners. In the years ahead it is vital that UiO makes the most of its competitive advantage as a university with academic breadth and a wide portfolio of knowledge and leading-edge competence – a solid basis for convergence. UiO must also assume the responsibility inherent in being the leading university nationally.

Interaction. Advances in the life sciences with an ever-increasing element of "big science", international networks and heavy infrastructure mean that the individual researcher working alone is not competitive. Today the researcher must be able to interlink different competencies, utilize advanced equipment, design demanding experiments and tap into informatics and statistics to make use of large data sets. Creating synergies between all these elements paves the way for success. In a well-functioning system, talents will also prosper. Funding is of prime importance in this interaction. Internal funding must be used strategically so as to increase the likelihood of obtaining external funding. Networks and partnerships must be built to enhance prospects for obtaining necessary funding from both national and international sources. External and internal drivers must work in tandem.

Research ecology. Variation and selection are also key elements in research. In an area such as the life sciences with many actors, a good balance between larger centres/priorities (selection) and smaller creative constellations (variation) is vital. UiO must be able to build

quality by both safeguarding established strong research environments and by encouraging young researchers to address new topics and research issues. The ambition to achieve convergence also includes a responsibility to foster new constellations across disciplines and organizational placements, and to improve opportunities for young, promising researchers. This implicitly means that outstanding researchers who are skilled in building research environments must be safeguarded. In this respect, the “strategic research groups” model which the Faculty of Mathematics and Natural Sciences has tested,³⁰ has been an interesting experiment. Another example is the BiO and NCMM centres which recruit talented, young researchers internationally who develop new research topics in collaboration with complementary environments established by close partners (see below).

Research management. Synergy is largely the responsibility of management. In the field of life sciences in particular with an increased element of convergence, sound research management will be of decisive importance in ensuring that different elements interact to improve research. We need managers who show great respect for academic competence and talent and who inspire colleagues to do their very best, but who also understand how to bring about the necessary cultural and organizational changes that are required. Such management will help to promote a sound research culture based on engagement, talent, knowledge and collaboration.

Compared with the situation only a few years ago, strategic research management today has been greatly enhanced. The faculties have deans and deans of research who promote UiO’s strategies actively, and the position of head of department includes a far greater element of strategic management than previously. Good organization promotes high-quality research and is crucial to the success of UiO. The University’s own MLS^{UiO} and the UiO and HSØ partnership body have promoted greater cross-cutting cooperation. Successful convergence will demand that this be further developed and professionalized.

Competitive subject development. To be competitive, UiO’s research must remain abreast of research advances internationally while also focusing on topics and technologies that will allow us to deliver relevant input. Even though much of this will be secured by international collaboration and national or international infrastructure, we must have adequate local competence to access networks and infrastructure that we do not have at our disposal. We must be attractive partners on the international arena in order to make use of the massive frontline research that is taking place internationally (absorptive capacity).

Bioinformatics, broadly defined as **computational life science** (CLS), holds a unique position. The development

in DNA sequencing technology has led to a tidal wave of genomic data that thrusts both biology and medicine in a digital direction. Other technologies, for example MR imaging or proteomics, show a similar development. We observe a growing number of theories, models and tools in statistics/mathematics/informatics as well as in quantum mechanics methods and multi-scale computations in which quantum mechanics is used to understand detailed mechanisms, while more macroscopic properties are studied using complementary computational methods. Those who successfully extract new knowledge from the large quantities of data will be among the top researchers of the future. A notable finding in the Research Council or Norway’s evaluation of biology, medicine and health sciences was that Norway fails to give sufficiently high priority to this area. Other countries invest considerably more. UiO is particularly well positioned to strengthen computational life science: it hosts the country’s largest informatics community, UiO and OUS together form Norway’s largest powerhouse for the life sciences, the mathematics and statistics environments at the University are strong, and modelling in theoretical chemistry and physics is at a high international level. Concerted efforts to strengthen this field will affect large areas of life sciences research, and will be decisive for success going forward.

Systems biology and systems medicine result from convergence processes and have close links to computational life science. Those who are most optimistic believe that this will lead to profound changes in the 21st century, and refer to “P4-medicine”³⁵ (Predictive, Preventive, Personalized & Participatory), based on the digital revolution in which large quantities of data can be analysed and individual parameters measured in the case of the individual patient. Another component consists of patient-activated social networks. A systems approach will provide new insight into disease mechanisms, emphasize individual variations, generate new methods and means of medication in addition to reporting how different organs are affected by the same disease. In concert this can result in personalized therapy tailored for each individual.

Another pioneering field is **epigenetics**, which shows how the packaging of genes carries genetic information and secures a different kind of heritable process than that known in classical genetics, which lasts two to three generations and is influenced by environment. We can also mention **bionanotechnology** – a merging of biology and nanotechnology; **synthetic biology**, biology’s answer to electronics; and **neuroscience** with its enormous potential for groundbreaking new knowledge, particularly in the linkage of everything from molecular biology to nanotechnology to physics and psychology. Common to all of these is that convergence plays a key role in the development.

2. Second pillar: Recruiting, training and developing talents

Specific strategic goals for training and recruitment

UiO will ...

- **offer an attractive, high-quality education in the life sciences which will attract the best students nationally and internationally**
- **give students in the life sciences a strong discipline-based expertise combined with experience in cross-disciplinary collaboration**
- **promote international mobility of students and research trainees in the life sciences**
- **develop interfaculty educational programmes that promote convergence**
- **secure staffing resources necessary for restructuring programmes of study**
- **include the innovation perspective and the dissemination of the life sciences in teaching**
- **test new categories of academic positions that allow for alternative career paths linked to life sciences research, in addition to the classical academic career path**

Implementation

UiO will ...

- make use of the teaching body across disciplines to boost the element of convergence in teaching
- promote the exposure of students and research trainees in the life sciences to research via the teaching, and provide contact with outstanding international researchers by means of guest researcher programmes, candidate work placements, travel grants and various kinds of exchange programmes
- familiarize students with the great societal challenges that the life sciences can help to solve
- exploit lecturers' own engagement in the life sciences to highlight the relevance of the subject
- employ opportunities to develop a broad, joint portfolio of courses in the life sciences as a step in building a new convergence culture
- work for changes in reimbursement rates for educational pathways in the life sciences if these represent impediments to further development of programmes of study with a greater element of convergence
- work for more unified parameters and routines for all educational pathways in the life sciences, and for the removal of administrative barriers to the desired development of the programmes of study
- utilize new mechanisms to recruit young talents to the life sciences, including by developing models for international recruitment

- help to ensure that the new tenure-track positions to be announced are organized such that they contribute to quality-based recruitment to life sciences research
- facilitate the involvement of students and research trainees in collaboration and exchange with the business sector
- develop the Centre of Entrepreneurship in relation to activities in the life sciences

Background

Talents are our most important resource. UiO must ensure that students with a talent for the life sciences are encouraged to develop this so that they become a resource for their environment and for society. The white paper on research underlines this perspective clearly. "Human capital is Norway's greatest asset ... investing in research, education and knowledge is the best way to manage this asset."⁹ UiO will be a higher education institution where talents can flourish and progress through their studies, research, interaction, involvement and innovation. UiO will pave the way for good career pathways for young gifted students regardless of whether they are intending to pursue an academic career or a career in society at large. Appointments to academic positions in the life sciences at the University will be based on excellent research, solid knowledge, pedagogical abilities and talent for collaboration and network building across traditional disciplinary boundaries.

Our students will shape society. The University of Oslo has a unique and central function as Norway's largest institution for education and research in the life sciences discipline, and plays a key role in shaping future research and competence in this field nationally. The majority of candidates in the life sciences in Norway graduate from UiO, and their competence and orientation influence – and will continue to influence – developments going forward.

The implementation of the convergence perspective in education and recruitment entails that course portfolios must be revised with this in mind. It is important to stress that convergence does not mean that students should learn a bit of everything, thus reducing the level of knowledge. Convergence functions at the group level. Individual students must continue to specialize and become strongly anchored in their discipline, but during their studies they should also be confronted with other disciplines. Through projects, teaching examples or in other ways they must be given the opportunity to hone knowledge of their discipline vis-à-vis other subjects. This will give them experience that will be useful in their later careers and will be part of the inclusion of the convergence culture in teaching.

The most recent white paper on research highlights the significance of a successful interplay between research, education and innovation. Students must become familiar with both international research and innovation opportunities at an early stage. The convergence perspective of the life sciences is well suited to exposing our bachelor's degree students to the breadth of research and innovation. Stronger internationalization must also be incorporated in education, which will require clear adaptation of courses of study and formalized, robust agreements between higher education institutions.

Recruitment to research is an important challenge. Norway has invested considerable amounts and today has a large number of young talents with a PhD and international experience who are highly motivated for a research career in the life sciences. The small number of career pathways is a challenge; competition for academic posts is fierce, and UiO like other ambitious universities recruits internationally so that talents must compete with candidates from strong international research environments abroad. Tenure-track posts may be one way of providing more predictable career pathways that are still competitive. New position categories linked, for example, to managing advanced infrastructure or data analysis, represent another career path that may prove attractive and that will help to professionalize UiO's research in the life sciences. An increase in the business sector's involvement in the life sciences will also provide more career options for our young researchers.

Education in the core areas of the life sciences is provided by three faculties: MN, MED and OD.

All three faculties offer programmes of professional education: pharmacy, medicine and odontology respectively. MED has a number of master's programmes, including in nutrition, general practice, health sciences, health management, health economics, medical ethics, community medicine and nursing science. Teaching focuses on disease, health and health systems.

MN has three bachelor's programmes and master's programmes in biology, molecular biology and chemistry respectively. Enhanced cooperation and coordination of teaching can greatly benefit all these environments, but constitute a challenge. Different reimbursement rates for similar teaching are a practical obstacle to such cooperation.

There are many educational pathways with a varying number of applicants and different admission

requirements, and the student body is heterogeneous both as regards prior knowledge and grade average. All 3-year programme descriptions contain basic courses that give all students a joint platform, but at the same time these courses claim considerable resources and hinder the specialization and breadth that is desired. More specific admission requirements for all programmes of study in life sciences at UiO will make it possible to increase the quality of the programmes and also the body of knowledge that students acquire during the course of their studies.

The master's degree programmes cover a wide educational range, with both practical and theoretical courses, many of which are attractive for master's as well as PhD students from all three faculties. While the majority of PhD students in life sciences at MED are medics, a fair proportion have their background in other disciplines, and a considerable share of the research activity at MED is conducted by employees with a firm basis in the natural science disciplines. For career pathways of this type, the existing programmes can be strengthened and enhanced by relevant courses in biomedicine, computational life science (CLS) and medical technology. In these fields there are numerous possibilities for innovation, both with regard to collaboration on courses in biomedicine, and in relation to other subjects such as physics, chemistry, mathematics and informatics (for example Computing in Science Education – CSE). Bioinformatics and computational life science in particular are of key importance, not least as an instrument to ensure student-active research.

The PhD programme at MED has recently been revised to include more optional course that allow for interdisciplinary course collaboration with MN, SV and BiO/NCMM. A joint strategy for the life sciences represents a unique opportunity to examine the links between PhD education at MED, OD and MN, and to create an environment in which PhD students in life sciences from all three faculties can avail themselves of the entire course programme in life sciences.

Use of the teaching body across disciplines requires strength and clarity of management, willingness to cooperate in order to put agreements in place that have clear framework conditions, as well as clearly defined roles and areas of responsibility, and not least adequate incentives linked to the collaboration.

3. Third pillar: Promote innovation for environment and health in the field of life sciences

Specific strategic goals for innovation

UiO will...

- **be a strategic and visible actor in the area of life sciences-based innovation**
- **contribute to the realization of the innovation potential in the life sciences through interaction and convergence**
- **train candidates in competences that are demanded by Norwegian businesses working with biotechnology and life sciences**
- **build a stronger culture of innovation and a clearer awareness among students and researchers of the benefit their research brings to society**
- **be active in an interplay between academia, the healthcare system and industry to promote innovation in the health sector**
- **make provision for applying the life sciences over a broad area of application in accordance with the expanded definition of life sciences**

Implementation

UiO will ...

- include perspectives and examples of innovation in its educational programmes in life sciences
- make use of Inven2's competence, with regard to both licensing and establishment of start-up companies, to stimulate enthusiasm for life-science research with commercial potential
- enhance the range of courses on innovation and entrepreneurship in UiO's educational life science programmes
- strengthen technology scouting in collaboration with Inven2 to find and develop unrealized ideas in the field of life sciences
- help innovation projects to reach further and not be terminated at too early a stage
- be an active participant in business clusters, networks and startup environments to promote innovation and value creation based on UiO life sciences
- use international research collaboration in life sciences as a springboard for innovation activity
- increase the number of industry-related PhDs in the field of life sciences in collaboration with relevant industrial actors, and engage co-supervisors with competence in innovation and/or relevant connections with industry
- enhance the visibility of the university's research vis-à-vis life science-based industry through proactive development of contact points and channels

- contribute actively to the establishment of a regional life sciences cluster with a role and mandate for UiO
- strengthen innovation activity in life sciences by learning from other sectors and utilizing the competence developed outside the actual core areas of the life sciences
- create culture that is open towards society, whereby the opportunities inherent in the life sciences are communicated, debated critically and developed responsibly in order to address key societal challenges

Background

Innovation is a broadly defined term. In UiO's action plan for innovation 2013–2015 it is defined as follows: "Innovations are new or substantially improved goods, services, processes, organizational forms or marketing models that are utilized for the benefit of society, including value creation."³² In medically oriented life sciences it may be defined as "new medicines, equipment or clinical practice introduced over time in the field of life sciences, or in the practice of health assistance". Innovation in life sciences will, however, also encompass innovations in environmental technology, food safety or production, plant cultivation, aquaculture, bioprospecting, green industrial processes etc. A common denominator for successful projects is that they build on collaboration between disciplines – in accordance with the strategy presented here.

Bioeconomics, which builds on research and innovation from life sciences, represents a growing share of the global economy with great potential for societal benefit, particularly in the areas of environment and health. The **BioVerdi** project focuses on value creation in all the Norwegian biosectors (marine, agriculture, industry and health). UiO participates jointly with other universities, R&D environments, and the bioindustry and capital and finance sectors. The project has analysed the status of innovation and originality and proposed measures to strengthen these. HelseOmsorg21 was recently launched by the Norwegian Ministry of Health as a national initiative that aims to enhance the interaction between academia, the health service and industry in the health and care sector.³³ The strategy developed in HelseOmsorg21 will be at the forefront nationally, with implications for several of the areas affected by the strategy presented here. UiO is participating in this work on a number of levels.

Inven2 is Norway's largest actor in the commercialization of research, and is owned by UiO and OUS. The life sciences currently comprise 75% of Inven2's

portfolio. Inven2's ambition is to build new industry based on groundbreaking technology from UiO and the university hospitals in the region.

In terms of biotechnology, R&D has undergone major growth from 2009 to 2011.³⁴ A total of almost NOK 3.8 billion in biotechnology R&D was reported in Norway (including total figures for industry) and spending on biotechnology R&D corresponds to more than 8 per cent of Norway's total R&D outlay.

Facts about Inven2

Inven2 ...

- has the most prolific supply of ideas of all the TTOs in the Nordic region (190 DOFIs in 2012)
- has a very high rate of commercialization: approx. 17%
- has signed more than 100 licensing agreements – the most lucrative to date has yielded approx. NOK 110 million
- has had the highest number of commercialisations in Norway in the last three years (25–30 per year)
- has more commercialisations than Karolinska Innovation (108 licensing agreements and 17 companies founded vs. 35 and 40)
- has a highly successful licensing strategy that attracts the attention of Nordic TTOs

Expectations and time horizon. Innovation in life sciences often comes about with unexpected discoveries as its main ingredients. There have been, and still are, high expectations for biotechnology, and this research has undoubtedly contributed to enhanced quality of life and longer life expectancy. As an example, mortality from cancer or heart conditions for patients younger than 85 years has fallen dramatically. However, the time horizon

with regard to this innovative work is frequently underestimated. Examples such as insulin, vaccines, cancer drugs and HIV treatment are based on scientific discoveries made a few decades before the drugs came onto the market. The long-term perspective is of the utmost importance for innovation in life sciences and medicine. It is to be hoped that current technological development and professionalization of commercialization processes will reduce the time horizon going forward. Much knowledge is generated in biotech companies that have their roots in academia, and close collaboration between industry and UiO is demanded in order to create the necessary total competence that leads to successful innovation. Innovation comes about via coordination between many actors, is driven by curiosity and requires ongoing communication and dissemination to create contacts and engender creativity. The constellation formed between UiO and OUS with their shared Inven2 provides a unique opportunity to exploit the short route from knowledge to practical application in several categories of innovation in the life sciences.

Demanding users represent a key driver of innovation, and the professional environments in the university hospitals have a central role to play in this respect. Those working in the hospitals are exposed daily to the need for improved patient treatment, and several of the most profitable innovations from Medinnova/Birkeland Innovation (now Inven2) have arisen because of such clinical needs.

Coordination, convergence and open collaboration enable new and successful innovations in the life sciences. As Norway's largest research and teaching institution in life sciences, UiO is an important driving force in this development.

Three cross-cutting approaches

4. First approach: Life sciences, ethics and society

Specific strategic goals for the relationship to the social sciences

UiO will ...

- **develop mechanisms to enhance the academic dialogue on issues related to the life sciences across traditional boundaries between medical/natural sciences (MedNat) and humanities/social science (HumSam) disciplines**
- **meet the considerable social challenges with a multidisciplinary approach that includes social science subjects and the humanities**
- **make provision for financial incentives for projects involving research at the interface between biology and society**
- **contribute to an evidence-based, ethically reflective social dialogue on real opportunities and new choices arising from the life sciences**
- **develop UiO's competence in ethics, economics and jurisprudence associated with biology and neuroscience, relevant for a sound and sustainable application of the life sciences in society**

Implementation

UiO will ...

- arrange workshops with participants from the field of MedNat and HumSam to promote cross-cutting project development in the life sciences
- consider separate incentive schemes to reinforce interfaculty research in the life sciences across traditional boundaries between MedNat and HumSam disciplines
- enable research competence from HumSam environments to be included in applications for major external research funding allocations for the life sciences
- use the social sciences actively in order to understand environment and social conditions as a cause of disease
- contribute actively to public debate on key topics at the interface between society and the biological and medical base of the life sciences, and enable an informed and reflective social dialogue on these topics

Background

In Strategy 2020, UiO has stated that UiO will be a “university transcending borders” and that “the strength represented by the academic breadth of the university will be utilised even better through interdisciplinary research and education.” The life sciences are an area suited for building bridges that transcend borders. For that reason, the social sciences and humanities are included in the definition “when these examine causal relationships between behaviour or consciousness and the biological foundation, or analyse challenges arising in the encounter between the application of the life sciences and society’s values and priorities.” When referring to causal relationships between phenomena such as consciousness or behaviour, the list could easily be extended further to include language, learning etc. The definition is intended to be inclusive. Also to understand the mechanisms that bring about the significant social changes in health and disease prevalence, the life sciences accord with the definition of this strategy (already included in the term “medicine”). At all these interfaces there is much unknown territory to be explored and new knowledge to be gained. Two-way communication and interaction will enrich and influence both parties and will help to develop UiO as a leading university in the life sciences.

Bridge-building is already well under way in areas of psychology where cognitive neuroscience explores the causal relationships between biology and behaviour or consciousness. Learning is another example – a key process for a university, for individuals, for our society, and as a phenomenon and discipline. In this area, bridge projects could be fundamental, groundbreaking and highly relevant, and the bridges could span from neuroscience to a long list of sciences at UiO, including linguistics and what is generally referred to as cognitive science. The Faculty of Social Sciences has strong environments in the area of cognitive neuroscience and research on integrated cognitive-neurobiological ageing, and has researchers participating in NORMENT.²² Both centres of excellence at the Faculty of Humanities, CSMN¹⁶ and MultiLing²², have special expertise in cognitive research.

Culture, environment, economics, society and biology constitute a complex whole with decisive significance for public health. Ageing is a good example, showing a complex interplay between basic biology and medicine on the one hand, and culture, psychology, economics, politics and social conditions on the other. In a few years we will have a far better understanding of what ageing is from a biological viewpoint. In parallel, humanities disciplines

will be able to provide other insights, interpretations and perspectives that amplify our understanding. Bridge-building will help to link together and exploit the various evidence bases on ageing, and give UiO the capacity to deliver important knowledge relevant for society to make provisions for welfare technology, preventive health care, economic challenges and so on.

The life sciences will give us many new opportunities and choices that challenge us as individuals and as a society. Examples range from personalized medicine to exploitation of biological resources in poor countries. We therefore need critical reflection and awareness of ethical issues, and tools to deal properly with ethical challenges. Research, conceptual understanding, analytical skills and the capacity for academic and ethical reflection are aspects of this. However, the challenges also transcend ethics. For example, the political, legal and economic frameworks for individual ethical choices associated with modern life sciences are crucial. In this respect, jurisprudence figures as an important area of competence in relation to the life sciences. There is clearly a need for statutory regulation regarding the use of modern biotechnology. Such regulation must be based on solid scientific knowledge, and with an approach that takes proper account of the demarcation between necessary regulation and respect for individuals' values, in order to safeguard the legitimacy of bioethical legislation.

As already mentioned, there are high expectations of an emerging bioeconomy. Economics is one of several social

science disciplines that can provide innovative environments in the fields of biology and medicine with important competence and research questions. An example from the TIK Centre for Technology, Innovation and Culture at SV is the Synergies and Tensions in Innovation in the Life Sciences (STiLS) study of innovation processes, actors and policy within the life sciences in the health sector,³⁵ or their studies of how biological material is given economic value through scientific and technical processes that create new forms of biocapital. The relevance ranges from the impact of new knowledge in the life sciences on the market economy, to what is termed neuroeconomics, in which neuroscientific knowledge contributes to the development of new models in economics as a research discipline. The way in which we make decisions in light of neuroscientific insights may have significant consequences for economists' models, for example.

The social science disciplines will, in general, also be able to provide critical assessments of how the life sciences can best be applied in society, and of the priorities and desirable direction for both research and application (innovation, implementation), in addition to contributing analyses of what is politically, economically and socially feasible in this area. This transcends the purely normative research questions.

5. Second approach: Interaction and internationalization

Specific strategic goals for collaboration

UiO will ...

- **be an engine for the life sciences, collaborating broadly at regional, national and international level**
- **intensify the internationalization of Norwegian life sciences through partnerships with the most attractive research environments, and by competing more actively for the best projects, researchers and students.**
- **build and further develop a research arena for the life sciences in collaboration with Oslo University Hospital (OUS) and Akershus University Hospital (Ahus)**
- **strengthen our cooperation with the Norwegian University of Life Sciences (NMBU)**
- **use the life sciences to promote translational research, clinical research and innovation, together with the university hospitals and other relevant research actors in the field of health**

Implementation

UiO will ...

- establish sound and functional cooperation agreements with some of the best research environments in the life sciences nationally and abroad, to promote joint research projects, put in place complementary infrastructure, create coordinated educational pathways, and enhance mobility
- develop SAK – cooperation, work-sharing and concentration – in the life sciences in the Oslo region, particularly in relation to OUS and NMBU
- promote mobility and create joint arenas regionally between the institutions, and pave the way for coordinated research management and joint applications for external funding
- work actively to achieve greater funding allocations from international sources, including through joint initiatives with OUS, NMBU and possibly other regional partners to obtain Horizon 2020 funds for life sciences research
- collaborate closely with the university hospitals in the region to ensure long-term thinking and a dynamic approach to the use of floor space, co-location, research and infrastructure
- help to exploit jointly with national and regional institutions the national advantages that biobanks, cohorts and registries represent in international collaboration

Background

Internationalization. UiO has a broad international interface and Strategy 2020 states that the University of

Oslo shall be a university transcending borders, both academically and geographically. This international engagement shall be expanded even further, and collaboration on research has been established with some of the best institutions in Norway's priority partner countries, to date especially with the USA, China, India and South Africa. Cooperation partners must be identified that are particularly relevant in the field of life sciences, and partnership agreements drawn up that make it attractive for scientists and research groups to develop joint projects and exchange researchers at all levels. UiO, OUS, NMBU and other research bodies in the region as a whole represent a dominant share of the life sciences in Norway. This entails a considerable responsibility for ensuring that life sciences research attains a high international standard that makes the environments attractive collaboration partners. Experiences from the centres of excellence in research, BiO and NCMM, show that this is possible. These environments have succeeded in attracting a significant proportion of researchers from abroad, and have strong international alliances.

Norway is a participant in European research cooperation. Norwegian life-science research environments have had varying success in applying for and obtaining research funding from the EU. Investment in the life sciences will sharpen the environments' competitive edge and opportunity to apply successfully for research funding. The EU's new framework programme Horizon 2020 has a clearer focus on innovation than previous programmes, and will meet societal challenges by building bridges between research and the market, for example by helping innovative companies to develop technological breakthroughs leading to products with commercial potential. The life sciences should be a strong competitor for funding from this programme. More robust, competitive research environments will also pave the way for larger disbursements from other funding schemes, perhaps the European Research Council (ERC) in particular. Agreements on joint funding schemes for research collaboration have also been established with a number of countries. A strong research environment in the field of life sciences in Oslo will be able to properly exploit these types of funding schemes.

Medicine and health. UiO has a particularly close cooperation with the university hospitals, OUS and Ahus, as well as the Norwegian Institute of Public Health. OUS is, for example, the University's largest partner measured in terms of the number of joint publications. UiO also has a rapidly growing research collaboration with Ahus, which includes a clinical health services research community with a firm basis in the social sciences. Parts of the Faculty of Medicine are closely integrated with the hospitals, with many students and teachers having study and work places

there, and through a joint line management structure whereby the heads of department have management responsibility for both hospital and university employees. Moreover, many have combined positions with an additional position as adjunct professor at the University. There is a broad cooperation between the hospitals and several other faculties. Joint research committees, as well as education committees with strong representation from UiO have been established at both university hospitals. The collaboration with South-Eastern Norway Regional Health Authority (HSØ) is endorsed by **the UiO and HSØ partnership body**. This committee distributes the earmarked research funding from the Ministry of Health and Care Services. The institutions also cooperate closely with regard to ICT and research infrastructure, including core facilities. The Oslo Centre for Biostatistics and Epidemiology (OCBE) is a recent example of a joint initiative between UiO and OUS. The establishment and operation of the EMBL node NCMM (see also Chapter 6 Infrastructure) is a joint project to which HSØ contributes funding and the centre's researchers have additional positions at the hospital. All the centres of excellence (SFF) and of research-driven innovation (SFI) in the field of medicine at UiO have been established in collaboration with OUS and are also the centres that receive funding from the Kristian Gerhard Jebsen Foundation. Inven2 is a joint Technology Transfer Office (TTO) for the two institutions, and represents a well-established, robust shared arena for research and innovation between UiO and the two university hospitals, which is already conducting significant life sciences research of very high quality. The university hospitals in the region are therefore key, natural partners in the university's investment in life sciences.

A shared research arena at regional level has implications for the coordination of infrastructure and premises. An assessment regarding the hospital of tomorrow is under way at OUS, a so-called concept phase, which is evaluating several possibilities, among which are a completely new hospital located at Gaustad, closely connected to central university premises. This paves the way for a unique win-win situation between UiO and OUS. A "Campus Oslo" of this type will provide unique opportunities to develop a shared arena for life sciences.

Translational research has grown rapidly in recent years. This links laboratory-based medical research more closely to clinical research to exploit research results in clinical work more quickly and effectively, for the benefit of patients. NCMM, all the centres of excellence and the K.G. Jebsen centres established as a collaboration between UiO and OUS have translational research as an explicit objective. Translational research is therefore a very important element of life sciences, and will constitute a

natural bridge connecting with clinical research and clinical testing of new therapeutic principles and drugs. The cooperation with Ahus will play an important role in this respect, particularly in light of the hospital's obvious strengths in terms of clinical research and clinical epidemiology. Much of this research may result in patentable inventions, and will promote innovation as described under Pillar 3. Oslotech AS, which runs the Oslo Research Park, is favourably co-located with the Biotechnology Centre and NCMM, and will be a natural partner.

Food and environment. Whereas the axis between life sciences and health research is largely directed towards the university hospitals in the region, the cooperation with NMBU concerns various aspects associated with environmentally related research and food production. NMBU focuses particularly on subjects related to bioproduction, on comparative medicine and basic bioscience disciplines. UiO has a number of environments that are relevant partners in this field, including a high-profile SFF that focuses on ecology and evolution (CEES¹⁴). Special SAK funding has been allocated from the Ministry of Education and Research to strengthen this axis. These environments can both contribute to and benefit from shared technology platforms and other infrastructure across the entire field of life sciences. This axis has great potential for further development, especially in connection with the extensive refurbishment and expansion that will take place at Ås with the new NMBU. When the merger with the Norwegian School of Veterinary Science is completed (from 2014), the number of employees will increase from 1200 to 1700. A strengthened actor with 1700 employees and new facilities will represent a particularly important strategic partner for UiO in relation to its investment in life sciences.

SAK. The government white paper Report no. 30 to the Storting (2008–2009) "Climate for Research" mentions cooperation, work-sharing and concentration (SAK) in the university and university college sector as an important instrument. Together with OUS, NMBU and other institutions in the region, it will be natural to profile the institutions working with different aspects of the life sciences, but simultaneously to have a shared platform and cooperation with particular regard to technology and education. Much of the research in life sciences will be technology-driven in the sense that new technology will open up new possibilities for research. By means of good infrastructure, advanced technology platforms and state-of-the-art laboratories (see Chapter 6 – Infrastructure), life sciences in the Oslo region will be placed firmly on the European research map and become a natural and attractive partner for the best research environments throughout Europe.

6. Third approach: Infrastructure

An important precondition for the success of the strategy presented here is an infrastructure that paves the way for the realization of our ambitions. This is particularly relevant for research infrastructure and buildings.

Specific strategic goals for infrastructure

Excellence in life sciences requires state-of-the-art infrastructure and exploitation of generically emerging technologies.

UiO will ...

- **erect a new life sciences building with modern premises that make provision for groundbreaking research and education with a large element of interdisciplinarity and convergence, and which will serve as a flagship for life sciences nationally**
- **formulate principles for moving into the building which ensure full and immediate utilization of a new life sciences facility, including for chemistry and pharmacy in accordance with the chosen concept**
- **develop a strategic organizational platform to optimize the use of a new life sciences facility**
- **ensure that front-line technology is available and that technological expertise in life sciences is continually developed further, since the infrastructural possibilities and new academic issues represent a mutual challenge**
- **exploit shared research infrastructure on a broad basis and cooperate regionally and internationally with regard to joint infrastructure and core facilities. Unnecessary duplication of infrastructure must be avoided, without thereby obstructing flexible utilization of smaller units.**
- **support life sciences research through strategic investments in infrastructure that benefit as many as possible of UiO's researchers in the form of enhanced research quality**
- **boost shared competence for the operation and use of research infrastructure in core facilities**
- **enhance the competitiveness of the life sciences environment with regard to applications for external funding for research infrastructure (nationally and internationally)**

Implementation

UiO will ...

- build robust core facilities for research and exploit the positive cooperation with OUS to coordinate the effort to establish core facilities with mutual access
- participate in the competition for national and European infrastructure for life sciences through coordinated initiatives with OUS
- cooperate with HSØ and the university hospitals with a view to establishing a national centre for particle therapy in the region
- set aside areas for innovation, explorative development and meeting places with business in future infrastructure

Background

Modern life sciences are dependent on a broad supply of research infrastructure, and elements of the research are largely technology-driven, in the sense that new technology is continuously being developed that makes it possible to answer questions which were previously impossible to address. We note that an increasing use of and need for "traditional" MedNat equipment and instrumentation characterizes modern developments in life sciences. This situation has some points of similarity with the development of chemistry at the beginning of the 20th century when physical chemistry emerged and introduced physical methods to a much greater degree into what had been an empirical phenomenological science. Today we see important contributions to life sciences from physics, ICT and chemistry. Of course, there is also a great deal of equipment that is specific to the life sciences, for example DNA sequencers and advanced optical microscopes of the highest quality. A proposed centre for particle therapy occupies an interesting intermediate position, and shows quite clearly how in-depth competence in the natural sciences meets medical needs.

The life sciences also clearly have a growing need for other types of research infrastructure than traditional instrumentation. Typically, these are needs linked to the collection, analysis and storage of large quantities of data, often in databases. These may be self-generated, open-source databases from international consortia, or commercial databases, with a broader or narrower area of application.

The ever-greater role of research infrastructure in the life sciences is attributable to development in both competence and technology. Standard instrumentation for physics and chemistry (for example NMR, MS, x-ray crystallography) has been developed to achieve a capacity

and solutions that enable them to be used on more complex systems such as we typically find in the life sciences. At the same time, equipment of this type has become more difficult to use, so that in addition to procuring and operating the equipment itself, there must also be an investment in high-level personnel, often with PhD degrees. A strategy for research infrastructure in the life sciences must aim to exploit the entire breadth of the field, so that top-quality research equipment can help to drive developments at UiO.

The recognition of the importance of infrastructure was key to the Research Council of Norway's major investment in functional genomics (FUGE) and forms the basis of the ongoing research infrastructure programme (INFRA). The investment in technology is especially evidenced in a European context by the establishment of ESFRI (European Strategy Forum on Research Infrastructures), a common European infrastructure with open access for

researchers to "state-of-the-art" technology that represents a uniquely important strategic instrument.

An important element of the infrastructure for the life sciences is floor space and buildings, particularly with a view to realizing a greater degree of convergence in research and education. Therefore, one of UiO's most important actions is to apply this concept as the basis for the planned new life sciences building which also includes new premises for the Department of Chemistry and the School of Pharmacy. A significant part of this facility will provide a setting for dynamic constellations that meet the convergence criteria. The realization of this type of concept demands a clear organizational endorsement and strategic dynamism. Intentions and guidelines for this new building are given in a separate appendix to this strategic plan.

Endnotes

1. “Century of the Life Sciences” has more than 13 million Google hits
2. *E. coli* bacteria ‘can produce diesel biofuel’
www.bbc.co.uk/news/science-environment-22253746
3. OECD 2009: The Bioeconomy to 2030: Designing a Policy Agenda
www.oecd.org/futures/long-termtechnologicalsocietalchallenges/42837897.pdf
4. National Bioeconomy Blueprint Released
www.whitehouse.gov/blog/2012/04/26/national-bioeconomy-blueprint-released
5. EU’s Lund Declaration 2009
www.se2009.eu/polopoly_fs/1.8460!menu/standard/file/lund_declaration_final_version_9_july.pdf
6. European Technology Platforms ETPs 2008: The European Bioeconomy in 2030 – Delivering Sustainable growth by addressing the Grand Societal Challenges
www.epsoweb.org/file/560
7. A New Biology for the 21st Century
www.nap.edu/catalog.php?record_id=12764#toc
8. MIT report “The Third Revolution: The Convergence of the Life Sciences, Physical Sciences, and Engineering.” Massachusetts Institute of Technology, January 2011.
web.mit.edu/dc/Policy/MIT%20White%20Paper%20on%20Convergence.pdf
9. Report to the Storting no. 18, 2012–2013, Long-term perspectives – knowledge provides opportunity
www.regjeringen.no/en/dokumenter/meld.-st.-18-2012-2013/id716040/
10. CCB: Centre for Cancer Biomedicine – a Centre of Excellence (SFF) at UiO in collaboration with Oslo University Hospital (OUS)
www.med.uio.no/ccb/english/
11. CMBN: Centre for Molecular Biology and Neuroscience (CMBN) was until recently a SFF at UiO in collaboration with OUS
www.cmbn.no
12. NCMM: Centre for Molecular Medicine Norway, one of four Nordic centres that comprise the Nordic EMBL Partnership for Molecular Medicine. NCMM is a joint initiative between UiO, HSØ and the Research Council of Norway, and operates on the basis of a consortium agreement with the European Molecular Biology Laboratory (EMBL).
www.ncmm.uio.no
13. CIR: Centre for Immune Regulation – a SFF at UiO in collaboration with OUS
www.med.uio.no/cir/english/
14. CEES: Centre for Ecological and Evolutionary Synthesis – a SFF at UiO
www.mn.uio.no/cees/english/
15. NHM – the Museum of Natural History, UiO
16. CSMN: Centre for the Study of Mind in Nature – a SFF at UiO
www.hf.uio.no/csmn/english/
17. Report to the Storting no. 12, (2012–2013), Long-term perspectives on the Norwegian economy 2013 – a summary
www.regjeringen.no/en/aktuelt/long-term-perspectives-on-the-norwegian-/id714178/
18. In simple terms, biotechnology is applied science. Biotechnology is generally defined as the application of science and technology to living organisms as well as to parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services. The term encompasses research, competence-building, and application of the many types of biotechnology. (National Strategy for Biotechnology, 2011–2020)
19. National Strategy for Biotechnology 2011–2020
www.regjeringen.no/en/dokumenter/national-strategy-for-biotechnology/id666235/
20. NORMENT: Norwegian Centre for Mental Disorders Research – a SFF at UiO in collaboration with OUS and the University of Bergen (UiB)
www.med.uio.no/norment/english/
21. BiO: the Biotechnology Centre of Oslo, UiO
www.med.uio.no/bio/english/
22. MultiLing: Centre for Multilingualism in Society across the Lifespan – a SFF at UiO
www.hf.uio.no/multiling/english/
23. An early use of convergence is found in the report “Converging Technologies for Improving Human Performance” (2002) from the U.S. National Science Foundation and the Department of Commerce. The link between nanotechnology, biotechnology, information technology and cognitive science, with the acronym NBIC, is central to the report. See www.wtec.org/ConvergingTechnologies/Report/NBIC_report.pdf. A closely related mindset is also found in A New Biology for the 21st Century: Ensuring the United States Leads the Coming Biology Revolution. National Research Council (US) Committee on a New Biology for the 21st Century.
www.ncbi.nlm.nih.gov/books/NBK32509/
24. UKCMRI or The Francis Crick Institute: Creating a world-leading centre for medical science and innovation in London. UCL. See www.ukcmri.ac.uk/ and www.ukcmri.ac.uk/scientific-vision/multidisciplinarity

25. Imperial College London has developed interdisciplinarity through a number of “cross-faculty” institutes, see www3.imperial.ac.uk/a_to_z
26. Biomedicum Helsinki, see www.biomedicum.com/index.php?page=108&lang=2
27. Heinze, T., Rogers, J., Shapira, P. and J. Senker (2007), Creativity Capabilities and the Promotion of Highly Innovative Research in Europe and the United States. Final report, Karlsruhe
28. Evaluation of research in biology, medicine and health in Norway (2010–2011) – publication and citation analysis. NIFU March 2011
29. UiO requisitioned more detailed analyses for its own activity from NIFU, which form the background of these figures. Note that prior to 2006 it was not possible to distinguish UiO separately from the health enterprises, therefore these are measured together, but the contributions are fairly evenly distributed among the institutions. The newest biology, molecular biology, is the category that has shown the clearest positive development in terms of citation frequency, from lowest of the five categories ten years ago, to highest at the end of the period – 38% above the international average.
30. Centres and focus areas, the Faculty of Mathematics and Natural Sciences, UiO
www.mn.uio.no/english/research/about/centre-focus/
31. Institute for Systems Biology
www.systemsbiology.org
32. Action plan for innovation 2013–2015, UiO (in Norwegian)
www.uio.no/om/strategi/dokumenter/handlingsplan-2013-2015.pdf
33. Health&Care21 – a national process aimed at developing a National Research and Innovation Strategy on Health and Care for the 21st Century in Norway
www.helseomsorg21.no
34. NIFU Report 18-2013 on biotechnological R&D 2011 (in Norwegian)
www.nifu.no/publications/1033645/
35. STiLS – Synergies and Tensions in Innovation in the Life Sciences (STiLS). See
www.sv.uio.no/tik/english/research/projects/synergies/index.html

APPENDIX

Implementation of new building – principles for utilization of new life science facility

“At the University of Oslo, the planning of a new research and teaching facility for the life sciences, including chemistry and pharmacy, has undergone external quality assurance (QA1). The Norwegian Government has decided that the convergence concept shall form the basis for the further planning of the project. This option entails a joint solution for chemistry, pharmacy and the life sciences in a shared facility.”

National Budget, autumn 2012,

www.regjeringen.no/nb/dep/kd/dok/regpubl/prop/2012-2013/prop-1-s-20122013/8.html?id=702360

- **This investment project aims to ensure international competitiveness for Norway in the life sciences for at least the next 30 years.**

From the “choice of concept” evaluation (KVU) for the new building.

It is important that going forward, UiO puts in place a good process for optimal utilization of a future new building.

There are three fundamental preconditions for use of the new life sciences building, apart from the fact that it will house the Department of Chemistry and the School of Pharmacy, namely that the activities in the new building shall ...

- constitute a **resource for the entire life sciences environment** at UiO and in the region, also for those who are not housed in the building
- function as a spearhead to **realize the vision of convergence**, so that the building becomes a powerful instrument for the realization of the strategy presented here and UiO’s Strategy 2020.
- make a clear contribution to securing **international competitiveness** for Norway in the life sciences by means of concomitant “spin-off” effects.

The Norwegian Government has opted for a total solution for chemistry, pharmacy and the life sciences with convergence as a leading concept. This means that two departments, the Department of Chemistry and the School of Pharmacy, acquire new premises, but also that a significant element of the building is envisaged for constellations in the life sciences that will have the important strategic task in developing and initiating activities that help to realize the convergence concept. Many relevant research environments at UiO must contribute to this in order to introduce competence from various disciplines and ensure that the full breadth of life sciences at UiO is reflected in the building. The activities

must be of such a nature that they constitute a joint resource for the many life science environments at UiO.

Until completion of the building, and parallel with the planning of structural aspects, a strategic disciplinary process must be undertaken that will be particularly important for creating the culture of convergence that is the ethos of the building. The strategy presented here must act as the guide, but the responsibility for the practical application and realization of this lies with management at the relevant levels.

The “choice of concept” evaluation (KVU) for the building outlines that it should house dynamic constellations. Centres of excellence or other centres, national research infrastructure with affiliated personnel, or other such types of strategic constellations are used as examples. The completion of the building is a far ahead, and UiO has consciously not defined at this stage precisely which temporary constellations should move into the building. This thereby avoids cementing the current landscape and locking the strategic space that the building represents.

We submit the following points as input to the discussion of the more specific principles that can form the basis for selection of the life science environments that will first be given space in the new building:

Constellations with space in the new building should ...

- have a clear convergence profile and represent innovative research based on interlinking of disciplines
- be able to point to outstanding research with international visibility
- have the effect of also raising the quality of research environments that are not given space in the new building
- safeguard synergy with their parent community
- be temporary and have space in the new building for a defined period
- If the constellation builds collaborative relationships with the building’s permanent activities, i.e. chemistry or pharmacy, this will count especially in its favour
- If the constellation builds collaborative relationships between different faculties at UiO, this will count especially in its favour
- If the constellation builds collaborative relationships with OUS, NMBU or other regional research institutions, this will count especially in its favour.

The University of Oslo, 19 November 2014



Life Science

UiO : University of Oslo