

OSLO KNOWS BIO

Unique strengths and opportunities

2006 edition



The Oslo region consists of Oslo, the capital of Norway, and the surrounding county of Akershus. Over one million people live in the region which is a gateway to the rest of Norway and the Scandinavian countries. Norway is an associated member of the European Union through the European Economic Area (EEA) agreement, securing full business access to the EU market with some 450 million consumers.

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WELCOME TO OSLO

– THE KNOWLEDGE REGION

The life science sector in the Oslo region has much to be proud of. Nonetheless, both public and private players are convinced that this is just the start of something greater. This report focuses on key strengths of the Oslo region in particular, presenting both the research and industrial sector. Oslo Teknopol is proud to work together with companies and academia to secure continuous growth and innovation in the life science sector. Access to unique talent, technology and quality of life are key advantages for companies doing business here, and we invite you to learn more about the business opportunities in the Oslo region.

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BUILDING ON UNIQUE STRENGTHS

- *Internationally renowned research environments*
- *A diverse red, blue and green biotech sector*
- *A sophisticated public healthcare market*
- *Steadily increasing state funding for R&D*
- *An enterprise-friendly regulatory atmosphere and solid public-private collaboration*
- *Infrastructural strengths in health registers and clinical testing*
- *Public support for medical and pharmacological innovation*

Norway and its largest life sciences market, the Oslo region, are characterised by their outstanding level of biomedical research and valuable discoveries within the life sciences. Previously a number of Norwegian companies have taken advantage of this strong atmosphere for research and development to create and commercialize products that have truly succeeded in the global market. Examples of these include Dynal Biotech and Nycomed Imaging (now GE Healthcare). Other companies have created products and compounds in Oslo that realised substantial profits when they were acquired by larger international companies for further development and commercialization. GenoVision, Inovio and GemVax are prime examples.

A NEW DETERMINATION

Since the turn of the century, Norwegian policy-makers in conjunction with some of the leading life sciences institutions in Norway have sought to pick up the pace, quality and quantity of biotechnological development in the country. From 2000 to 2005, the Norwegian government has increased research funding destined for health-related projects considerably. A White Paper has also identified biotechnology as a priority for maintaining national competitiveness. New technology transfer offices, new laws on commercialization of research, an increased focus on intellectual property rights, increased public support for venture funding, improved international benchmarking and national tax initiatives to promote innovation aim to open a new chapter for life sciences in Norway. This time, however, there is also a determination that these activities will lead to a more balanced sector with a greater proportion of companies seeking to develop fully and move along the value chain. Already with companies such as Biotec Pharmacon, DiaGenic, Clavis and Navamedic choosing to list in Oslo, the signs are promising.

RESEARCH: THE FOUNDATION

Norway's and Oslo's greatest strength in the life sciences still lies in the quality of the research conducted here, and the access to one of Europe's most highly educated workforces. Whilst cancer research is well known, outstanding advances have been made in other areas as well. In cardiovascular research for example, three of the seminal trials – on beta-blocker, ace inhibitors and cholesterol lowering drugs – were performed here. Similarly four of the key discoveries in neuroscience were made by Oslo-based scientists. Therefore Norway's strategic focus is on those areas where Norwegian research is of the very highest calibre: functional genomics, cancer, neuroscience, cardiovascular, immunology and blue and green biotech research. New research groups are highlighted in this report, along with some of the increasing number of top international researchers choosing to make Oslo their base.

OPEN TO INDUSTRY

Among other key advantages in the region is the willingness to encourage the industry. The section on the Oslo region's diagnostics and imaging industry describes one of the major ongoing successes in the Nordic countries. An increasing tendency for international firms such as GE and Applied Biosystems to use Oslo as a testbed for new technologies and ideas is described, including the latest departure - wireless medicine networks. Excellent patient recruitment and follow-up thanks to the patient registry system means Oslo is also highly rated by pharmaceutical companies such as MSD, Roche, GSK and Pfizer for high quality clinical trials, as the case study for AstraZeneca further confirms.

A BOOMING CLUSTER WITH REAL SUBSTANCE

In line with the general increase in support for biotech, the Oslo region aims to continue to be the center of

a booming cluster of biotechnological innovations, enterprises and collaborations. With its four clinical and research hospitals, numerous research institutes within life sciences and close international links, the Oslo region is well positioned both with respect to public-private co-operation and international collaboration. Infrastructural strengths in health registers, clinical trials and public support also lay a solid foundation for future growth. Furthermore, developing life sciences forms a major part of the "Capital City Project". A collaborative network with stakeholders from life sciences in the region - called Oslo Bio - has been established to strengthen the cluster and contribute to long term growth within life sciences by facilitating and coordinating projects and promoting international collaboration.

HIGH CONCENTRATION OF BIOMEDICAL ACTIVITY

Gaustadbekkdalen in Oslo represents one of the most concentrated physical campuses for bio-medical activity in the Nordic countries. The anchor at Gaustadbekkdalen is the close co-operation between Rikshospitalet, Norway's largest and most specialised hospital, and the neighbouring University of Oslo. Also at Gaustadbekkdalen are a large division of SINTEF, the

Nordic countries' largest independent applied research organization, the Oslo Innovation Center, which – after a new expansion – will become one of the Nordic countries' largest research parks, and the GlaxoSmithKline Innovation Center, a combined headquarters, incubator and conference center.

In short distance to Gaustadbekkdalen, Montebello is home to the world famous Radium Cancer Hospital which has spun out a multitude of cancer-related companies such Dynal, Algeta, GemVax and PhotoCure. Building continues apace with a new Radiation Center, and the area is now being mooted as the site of a new science park to enhance the recently launched Oslo Cancer Cluster.

In a beautiful countryside setting to the south-east of Oslo, the Ås campus is the focal point of green and blue biotech research. The campus includes the University of Life Science, MATFORSK, Bioforsk, Bioparken and the AKVAFORSK research institute. The latter institution specialise in breeding programmes, fish feed, and product quality, along with the Aquaculture Protein Center. Ås is also home to CIGENE, a FUGE center providing integrated genetics research services to other institutes.

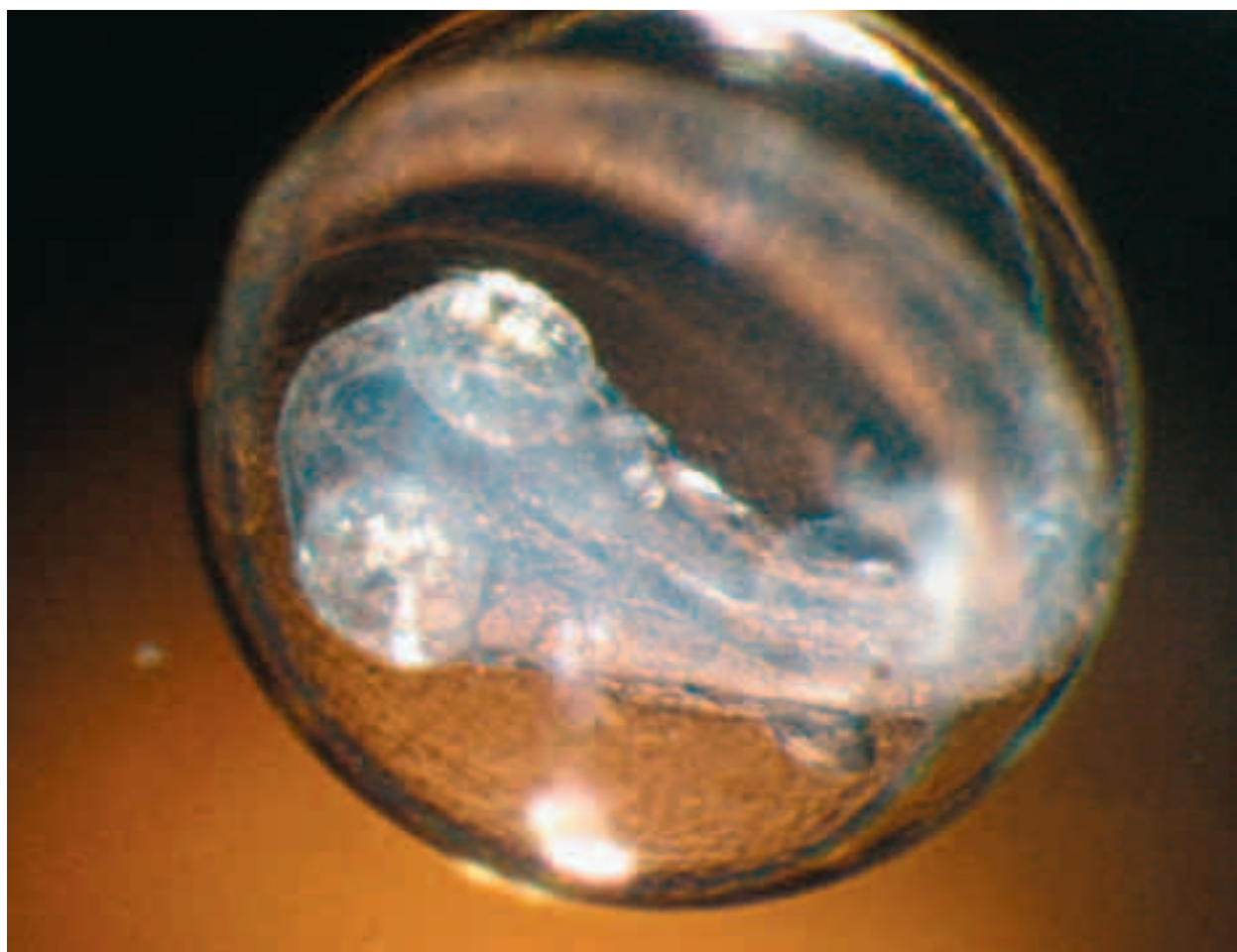


PHOTO: Institute of Marine Research/Havforskningsstasjonen Austevoll

FUNCTIONAL GENOMICS PROVIDES

A MAJOR FOUNDATION FOR NORWEGIAN SCIENCE

FUGE is the Norwegian state funded Functional Genomics programme which both coordinates research and stimulates commercial activity in this important field.

Oslo is home to several FUGE centres for red, blue and green activities which are described here and in the Blue & Green section.

A MAJOR SUCCESS

In 2002, the Research Council of Norway declared functional genomics a priority for Norway and launched its FUGE (or FUncTional GENomics) programme across the fields of human, animal and plant genomics. As one of seven large national programmes funded by the council, FUGE pumps roughly NOK 170 million into public and private research efforts, and eleven technology platforms. Thanks to FUGE's coordinated national approach and its development of R&D platforms, functional genomics and its related fields are blossoming both in the Oslo region's scientific community and Norway in general. Several FUGE research groups – in particular marine and agricultural genomics - are already clearly world class, whilst new commercial collaborations and actual companies have been established as a result of the programme. Driven by professor Ole Petter Ottersen, the goals remain highly ambitious – the Research Council now sees functional genomics as an area of strategic importance for the country and its industry. With this recognition, funding has recently been extended through to 2011.

BIOBANKS AND RELATED EXPERTISE IN DEMAND

Biobanks for Health, for example, is led by the Norwegian Institute of Public Health in Oslo and takes advantage of the universal patient registry system in Norway. Two population-based sets of historical health data, one general cohort and one mother-child study are being organised. This unique epidemiological data from as much as one-tenth of the Norwegian population makes the biobank among the world's largest.

Overall development costs amount to as much as NOK 450 million over several years, of which FUGE funding totals NOK 50 million. The resulting biobank platform has already led to new projects funded by National Institutes of Health (US), the EU and the Norwegian Research Council. DNA extracted from biosamples are available to Norwegian researchers and international project partners. Already the signs are that these studies will deliver insights into diseases with suspected high environmental – genetic interaction such as autism, ADHD and Type 1 diabetes.

INTERNATIONAL COLLABORATIONS GROWING

Stable, long-term funding has been the hallmark of FUGE-funded projects. The FUGE programme has also created a lighthouse effect as it attracts international co-operation and EU grants. FUGE has already established equal access to Swedish genomics infrastructure for Norwegian researchers, and plans to add similar agreements with national genomics initiatives in Denmark, Iceland and Finland.

A MAJOR BOOST TO THE BIOTECH INDUSTRY

Commercial development of advanced research has also been accelerated through research grants to several established and emerging companies in the Oslo region, including Affitech, DiaGenic, Genpoint, Spermatech and Biotech Pharmacon, an aggressive patenting strategy and strict guidelines requiring private participation in research projects.

“FUGE is a world-class program which has enabled Affitech to build a more diverse research pipeline than would have been possible using only our own resources.”

Martin Welschhof,
CEO, Affitech

CIGENE

- BUILDING UP EXCELLENCE

FUGE's national action plan states in black and white that a central goal is to build world-leading research groups. Only a few years after FUGE's inception, CIGENE at the Norwegian University of Life Sciences at Ås, Norway has gone a long way towards achieving this aim. GIGENE stands for Centre for Integrated Genetics, and the group certainly practices what it preaches with linked programs investigating the underlying genetics of fish, animals and plants. In August 2005, Genome Canada gave a large grant to the CIGENE group together with Canada's Simon Fraser University and University of Victoria. The grant aims to develop the group as international leaders in salmonoid functional genomics. Efforts to establish funding and organization necessary to sequence the Atlantic salmon genome are already underway with the first major conference being held in Oslo in 2006. Nor are efforts restricted to salmonoid species, cod is also being investigated with others in the pipeline. From 2003 to 2006, CIGENE published approx. 65 papers in refereed leading scientific publications and 10 book chapters. It has completed about 50 SNP genotyping projects for external users, initiated the development of a new and highly versatile technology for SNP genotyping and cooperated with a host of Oslo institutions on systems biology projects.

www.cigene.no.

FUGE'S TECHNOLOGY PLATFORMS ARE:

Biobanks for Health – *A Norwegian network of human research biobanks and health studies*

The Regional Research Biobank in Central Norway

The Norwegian Bioinformatics Platform

The Norwegian Centre for Integrative Genetics (CIGENE)

The Norwegian Arabidopsis Research Centre (NARC)

The Norwegian Centre for Microarray Technology (NMC)

The Norwegian Structural Biology Centre (NorStruct)

The Norwegian Proteomics Centre (PROBE)

The Norwegian Centre for Microbial Technology (CAMST)

The Norwegian Molecular Imaging Centre (MIC)

The Norwegian Transgenic Center

www.fuge.no

BiO

- LEADERS IN CELL SIGNALLING

The University of Oslo's Biotechnology Centre of Oslo (BiO) has focused its efforts to be one of Europe's leading centers for research on cell signalling. The centre's director Kjetil Taskén is successfully using FUGE funding to grab ambitious young scientists from around the world to lead his research groups. Already BiO has some 60 staff including international recruits at all levels - group leaders, postdoctoral scientists, Ph.D. fellows, students and technical and administrative staff. The six research groups - Kjetil Taskén, Hilde Nilsen, Hans Prydz, Bernd Thiede, Farrukh Chaudhry and Ian Donaldson - apply functional genomics to studies of cellular communication and

signalling. Specifically the Taskén group studies receptor-mediated signalling and protein phosphorylation. The Nilsen group studies DNA damage signals whereas the newest group headed by Dr. Bernd Thiede, will study cell signalling and apoptosis. Various functional genomics methods and approaches are being pursued at BiO and encompass proteomics, and interactomics, bioinformatics, molecular imaging and array analyses. Genome and proteome-wide studies are being conducted in human and animal models as well as in genetic model organisms such as *C. elegans*.

www.biotek.uio.no

“Among FUGE's many advantages for both public and private research organisations, is the move to larger funding amounts and longer periods, which enables researchers to focus on discoveries and companies to focus on technology and product development.”

Kjetil Taskén,
Director, BiO

“Oslo gave me better position than before, a clear financial package for 5 years including necessary instrumentation and the opportunity to be part of the development of an institute and to build up my own group.”

Bernd Thiede
(formerly of the Max Planck Institute in Berlin)
recently appointed head of proteomics research group,
Biotechnology Centre of Oslo.

CANCER

A MORE POSITIVE APPROACH

Cancer is the research strength par excellence in the Oslo Region and has also led to major commercial successes, from Nycomed Amersham (now GE) imaging systems to PhotoCure's PDT therapy. This section describes the depth of resource and the major new Oslo Cancer Cluster initiative which aims to create the leading center in Europe for cancer diagnostics and treatment

FORWARD WITH THE OSLO CANCER CLUSTER

Of all the areas of biomedical research, it has received by far the largest and most continuous support. Furthermore, the vast majority of Oslo's several hundred biotechnology, pharmaceutical or diagnostics companies are entirely or at least partially cancer-related. However, as this report went to press in 2006, this world-renowned sector was given a further boost with the launch of the Oslo Cancer Cluster. This powerful new initiative unites all the various stakeholders – academic, public, government and industrial – and aims to become the most innovative and creative center in Europe for cancer diagnostics and treatment. First steps include the new Centre for Stem Cell-based Tumour Therapy (SENIT) described below, a possible new seed fund and science park and applying for Norwegian Center of Excellence status.

BUILDING ON RADIUM'S HERITAGE

The Oslo Cancer Cluster is built on strong foundations. Dating from the early 1900s, Oslo's Radium Hospital is now Northern Europe's largest comprehensive cancer centre. Already, together with the Center for Cancer Research and the Norwegian Cancer Registry, the Norwegian Radium Hospital has built a dynamic biomedical cluster for research into cancer and commercial spin-out of cancer diagnostics and therapies. The Center for Cancer Research is best described as an international reference institution. The centre's research recently earned the characterisation "very good on the border of outstanding" by international auditors, and it co-operates extensively with the National Cancer Institute (US) and other leading cancer research institutions in the US and EU. Several of the institute's group leaders are leaders in their field and co-operate closely with researchers and industry. The institute is investing NOK 1 billion into a new research building that will be complete in 2009.

CANCER REGISTRY THE PRICELESS ASSET

The Cancer Registry's database contains over 50 years of information on all cancer cases and pre-cancerous diagnoses in Norway. The registry is developing numerous clinically-oriented special registries for various tumor forms. Its epidemiological cancer research covers a wide number of projects, and resulted in 70+ scientific papers in 2005. The registry's funding comes directly from the national budget, via Norwegian and EU research projects and some private partners.

Furthermore, in 2005, as a precursor to the Oslo Cancer Cluster, Radium merged its operations with another of Oslo's largest institutions for the treatment and study of cancer, at Rikshospitalet.

Given the duration and focus of cancer research in Oslo, it is not surprising that the region has become a hotbed for commercial innovations in cancer therapies and diagnostics.

COMPANIES EMERGING FROM OSLO'S STRONG CANCER ENVIRONMENT INCLUDE:

Nycomed (now part of GE Health Care)
– contrast media for x-ray and MRI

Dynal Biotech – biomagnetic separation

PhotoCure – photodynamic cancer therapy

GemVax – peptide cancer vaccines

Clavis – cancer therapeutics

Algeta – cancer therapeutics

Affitech – antibody therapeutics

CancerCure – ultrasound activated therapy

PCI Biotech – cancer therapeutics

DiaGenic – gene expression cancer diagnostics

Alpharma – cancer therapeutics

Biomolex – diagnostics instrumentation

For more information on companies in Oslo and Norway see:
www.norbiobase.no

CENTER FOR STEM CELL-BASED TARGETED TUMOUR THERAPY

- *studying stem cell characteristics in tumors*

The newly formed Center for Stem Cell-based Targeted Tumour Therapy (SENIT) is an exciting Norwegian Research Council funded consortium bringing together leading Oslo-based researchers and companies. Their aim is to look at the "bad" side of stem cells - their potential to develop, under certain circumstances, into tumors. Using the stem cell toolbox, researchers at SENIT work towards identifying tumour stem cell markers that can form the basis of novel diagnostics and therapeutics. Coordinated by stem cell researcher Stefan Krauss, the consortium makes full use of the synergies between the internationally known cancer environment at the Radium Hospital and selected stem cell research groups at the University of Oslo and Rikshospitalet. Participating research groups include Harald Stemmark in Biochemistry who will be involved in identifying signalling mechanisms, the teams of Gunhild Mælandsmo and Ola Myklebost who will be focusing on identifying side populations in the search for novel markers, and Joel Glover at the Department of Medicine who will look at tumor cells with single cell resolution. Preclinical tumor

models will be the focus of Therese Sørli and Ragnild Lothe at the Genetics department, while Gustav Guadernack and Steinar Funderud at the Immunology department aim to develop new tumor vaccines based on the findings of the involved researchers.

COMMERCIAL OUTLOOK

A key strength of the novel Centre is the participation of highly complementary leading Norwegian biotechnology companies that contribute their diagnostic and drug development technologies and expertise to SENIT - Affitech, Photocure and Alpharma, along with Radium "alumni" (Dynal) Invitrogen and GemVax. As the project progresses further collaborators from both within Norway and internationally will be sought. The Center also promises to pave the way for further applied stem cell research as Krauss and Funderud are centrally involved in the Norwegian Centre for Stem Cell Research.

www.stemcell.no

BREAST CANCER DIAGNOSTICS TESTBED

- *Radium teams up with Applied Biosystems, Inc.*

Starting in May of 2005, Applied Biosystems set up a Center of Gene Expression and Discovery [CGED] at the Department of Genetics at the Norwegian Radium Hospital. The center of excellence, along with five other centers worldwide, will help Applied Biosystems develop new products and innovations in gene sequencing and expressions. The Radium Hospital has contributed four research groups and new equipment funded by the hospital's own grants to the center. Applied Biosystems, a leading developer and marketer of instrument-based systems, consumables, software, and services for chemical and biological analysis, is supporting the project with databases and informatics.

One of the primary investigators at the Norwegian Radium Hospital, Dr. Anne-Lise Børresen-Dale, describes why they were selected as an Applied Biosystems CGED: "We were one of the key investigators in the research of arrays for breast cancer. And we have used high-quality sequencing studies." Applied Biosystems' manager for gene expression market development Richard Henfrey said: "[the CGED] is designed to enable thought leaders with cutting edge gene expression technology, including bioinformatics and application support, to translate 'data to biology' more effectively and efficiently, hence to drive publications."



PHOTO: The New Radiation Oncology Building at the Norwegian Radium Hospital, RR HF-foto, Thea Tønnessen

NEUROSCIENCE

A GROWING NODE

Neuroscience in Oslo is one of the fastest growing research areas driven by the CMBN and an increasing number of world class research groups such as NDVEI. Stem cells are also becoming a hot topic. From this strong base, a number of commercial opportunities are starting to arise.

A RECORD OF KEY RESEARCH BREAKTHROUGHS

Several key discoveries in neuroscience have involved Oslo-based researchers. Back in 1966 LTP (Long-Term Potentiation) was first observed by Terje Lømo in the laboratory of Per Andersen. There, Lømo conducted a series of neurophysiological experiments on anesthetized rabbits to explore the role of the hippocampus in short-term memory. Jon Storm Mathisen first identified and continues to work on characterising glutamate as a neurotransmitter, Per Andersen LTP. Recently deceased Erling Seeberg was also a giant in the field bringing major hope to sufferers with his work on repair enzymes. Currently Ole Petter Ottersen's group is unravelling the role of water channels and imbalances in neurological disorders, while Joel Gardener's group are looking neural stems and spinal cords. Again the "Oslo advantage" of having such leading researchers working in such close proximity has facilitated the creation of a center of excellence called the Center for Molecular Biology and Neuroscience (CMBN). Add in four university hospitals each with research groups in neurology, neurosurgery and related fields and the foundation for the dynamic neuroscientific community that exists in the Oslo region becomes clear.

CMBN POWERS FORWARD

The Norwegian Research Council named CMBN a center of research excellence in 2002. This status came with a grant of NOK 21 million per year, divided among the centre's eleven research groups – all headed by distinguished scientists. CMBN is determined to take on a leading role in elucidating the importance of DNA repair and genome maintenance mechanisms in preventing neurological disease and brain ageing. Its staff of 120 researchers published 50 papers in international journals in 2005; 24 of these were in so-called high-impact publications (ISI > 6). As home to some of Norway's leading research groups in molecular biology, the neurosciences and stem cells, CMBN plays a crucial

gateway function in international research. Its list of guest researchers includes Peter Agre of Johns Hopkins – winner of Nobel Prize in Chemistry 2003 – and it has won a co-ordinating role in a series of Nordic and EU research projects (see "A Neuroscientific Node"). In addition, CMBN co-operates with a number of biotechnology and pharmaceutical companies worldwide and is developing its own commercialisation portfolio.

PAIN AND EPILEPSY TREATMENT EXCELLENCE

Rikshospitalet, along with the University of Oslo, is co-host to CMBN and a national centre for neuroscientific research and therapy. A research and treatment center for epilepsy and a national skill centre for the study and treatment of pain at Rikshospitalet have spawned influential research and increased focus and investment from national authorities, including a new building for neurophysiological examinations at the epilepsy center (opened October 2006). In 2005, the hospital established PET facilities for use in neurology and oncology; the NOK 100 million investment came from Amersham Health (part of GE Health Care) and public authorities including the Norwegian Research Council. An animal PET scanner, financed by the University of Oslo, was installed in spring 2005 under the auspices of CMBN.

CROSS FERTILISATION PAYS DIVIDENDS

Also worth mentioning is the Neuropsychiatric Research Group at Rikshospitalet which represents a joint research team from different departments: Radiology (fMRI, MRI, SPECT, PET); Neurology (EEG, qEEG, clinical neurology) and Psychosomatic and Neurobehavioural Medicine (Neuropsychology, ERP, genetics; clinical neuropsychiatry). There is a close collaboration with Institute of Psychology, Faculty of Social Sciences, and the University of Oslo. Their main focus of research is on neurobiological aspects of bipolar II disorders and Recurrent Brief Depression (RBD). Other studies include

“The tradition of neuroscience research, combined with the proximity of colleagues and opportunities to share ideas, makes Oslo an ideal research location.”

Ole Petter Ottersen,
Director of CMBN.

neurobehavioural studies of temporal lobe dysfunction, the genetics of psychosis from a transgenerational perspective and early neurobiological assessment of dementia including ERP and neuropsychology. In addition to these four central institutions, the University of Oslo’s Institute of Molecular Biology and Faculty of Pharmacy also execute research into neurobiology and related pharmaceuticals.

IN GENERAL, THE NEUROSCIENTIFIC RESEARCH FIELDS COVERED BY OSLO’S FOUR UNIVERSITY HOSPITALS INCLUDE:

Cerebral vascular sicknesses

Cerebral Pathophysiology

Neurodegenerative/Metabolic sicknesses

Epilepsy

Brain Edema

Cerebral tumors

Developmental handicaps

Pain research

Neurotraumatology

Neurooncology

Neurogenetics

Anesthesiology

CMBN

- Extending collaborative and commercial connections

CMBN’s influence has led not only to designation as a Norwegian Center of Excellence (CoE), but also role as both key co-ordinator and participant in two of three projects sponsored by the Nordic CoE in molecular medicine. CMBN is leading the project on water imbalance-related disorders, and contributes to the project on neurodegeneration. The projects will receive EUR 2 million/year until 2009. In addition, the stem cell research group under the guidance of Stefan Krauss at CMBN is leading a Northern European stem cell research project funded by the Nordic Research Board. On their main interests is forebrain development and neural stem cells. The director of CMBN Ole Petter Ottersen and his research group is also lead project partner in an EU 6th framework project on “Glutamate Receptor Interacting Proteins As Novel Neuroprotective Targets (GRIPANNT)”, with 9 partners throughout Europe.

COMMERCIAL CATALYST

On the commercial front, CMBN has widespread collaboration with private biotech and pharma companies (such as Neurosearch in Denmark), but Ottersen indicates that this will increase as the Norwegian CoE funding eventually wraps up in 5-10 years and new funding becomes a priority. CMBN already has commercialization portfolio consisting of two projects supported by Birkeland Innovation, a Technical Transfer Office (TTO) owned by The University of Oslo. The Centre is also a partner in two spin off companies.

NDEVI

– Pioneering brain stem and spinal cord research

The Laboratory of Neural Development and Functional Imaging (NDEVI) headed by Joel Glover at the Department of Physiology, Institute of Basic Medical Sciences, University of Oslo possesses internationally recognized expertise in brain stem cell and spinal cord development, neuronal tracing techniques, and dynamic methods for functional neuronal imaging. NDEVI is affiliated with the Norwegian Center for Stem Cell Research (www.stemcell.no) and the Senter for Research-based Innovation, Stem Cell Based Tumor Therapy (SENIT). Glover has also coordinated an EU-supported research consortium (Brainstem Genetics, www.brainstem-genetics.org) and is member of a Human Frontiers Science Program consortium (Genetic Dissection of Neural Circuits Controlling Locomotion). NDEVI collaborates with laboratories throughout the world, including in the U.S., Canada, England, France, Germany, Sweden, Denmark, Spain, Italy, Hungary, Mexico, and Japan. Research interests include the development of the nervous system, principally of motor circuitry in the brain stem and spinal cord; spinal cord regeneration; stem cell biology, currently focused on the potential for neural differentiation of adult human somatic stem cells; and the evolution of the chordate nervous system. The spinal cord research program at NDEVI has recently been awarded a grant from the Christopher Reeve Foundation.

GAUSTAD NEUROSCIENCE NETWORK

- Linking like minds

In 2004, CMBN and Rikshospitalet established the Gaustad Neuroscience Network to stimulate increased co-operation between the two leading neuroscience hubs in Oslo. Both research and commercialisation should benefit. In the same year, a governmental study of neuroscience at hospitals in the Oslo region concluded that neuroscience research and practice should be centralized and rationalized in Oslo and between the four hospitals. All parties recommended expanding the scope of the Gaustad Neuroscience Network. Stronger neuroscience organisations in Oslo combined with closer affiliations with centres in Gothenburg and Copenhagen via MedCoast Scandinavia and Medicon Valley will create a strong global market for neuroscience research and commercialisation.

“The strong neuroscience tradition in Oslo, dating back to early in the last century and represented today by many excellent laboratories at a number of institutions, is helping my group and others create an internationally competitive neuroscience research community here.”

Joel Glover,
Department of Physiology, Institute of Basic Medical
Sciences, The University of Oslo



PHOTO: The New Radiation Oncology Building at the Norwegian Radium Hospital, RR HF-foto, Thea Tønnessen

A STIMULATING ENVIRONMENT

Immunology research in Oslo is linked to areas such as cancer and has led to breakthrough work on vaccines by companies such as GemVax. Mucosal immunology is another strength at the pioneering CEVI thematic research group, whilst Lauras and Bionor are looking at HIV vaccines.

FROM TRANSPLANT IMMUNOLOGY TO CANCER VACCINES

The most effective testament to the strength of immunology research in the Oslo region is its success in publishing, developing new knowledge and new technologies. Powered by large immunology research departments at the Norwegian Radium Hospital and Rikshospitalet (by far the largest department of its kind in the region), advances in immunology in Oslo, and particularly HLA complex, transplant immunology, mucosal immunology and cancer vaccines, contribute to the growth of knowledge in the field and more effective medical treatment.

INSTITUTE OF IMMUNOLOGY LAYING STEM CELL FOUNDATIONS

The Institute of Immunology at Rikshospitalet led by Eric Thorsby, has a staff of roughly 130, and a steadily climbing number of publications. From 1999 to 2006, the institute's sum of publications per year has grown from roughly 20 to over 60. At the same time, the proportion of articles with an impact factor of 2.5 or more has grown from less than half of the total to well over half. The institute's annual report testifies to broad international co-operation and influence. The Institute has made significant discoveries within transplantation immunology and HLA (human leukocyte antigens), which in turn have led to commercially successful methods and technologies.

A number of discoveries at the institute have been reached through co-operation with Oslo's Dynal Biotech, now part of the Invitrogen Corporation, the most successful of these a test of tissue types for transplant patients. The institute focuses on four main research areas: molecular and cellular immunology, functional immunogenetics, HLA and disease, cell therapy, and complement and innate immunity. In the cellular area in particular, the work is laying the basis for future stem cell applications with research into signal transduction in hematopoietic cells including the riddle of molecular memory.

RADIUM STUDIES CANCER LINKS

Smaller than Rikshospitalet's institute, the Department of Immunology at the Norwegian Radium Hospital excels at those areas of immunology that directly or indirectly apply to cancer. The department has five research groups working on bone marrow biology and hematopoiesis, molecular immunology, lymphomas and lymphocyte biology, molecular medicine and immunotherapy. Another institute involved in immunological research is the Biological Institute at the University of Oslo. There research groups study antibodies and, their use in treating diseases such as cancer, arthritis and multiple sclerosis.

CENTRE FOR VACCINOLOGY AND IMMUNOTHERAPY (CEVI)

- a thematic approach

Seeing a major opportunity for synergies in basic immunology research inspired Per Brandtzaeg in 2001 to bring together five research laboratories – three at Rikshospitalet, and two at the main campus of University of Oslo - in a thematic research group named Centre for Vaccinology and Immunotherapy (CEVI). Brandtzaeg's confidence in this approach has been more than justified. After the merger of two hospitals in 2004, Gustav Gaudernack's laboratory at the Radium Hospital joined and in 2005 CEVI and nine other thematic research groups of the Medical Faculty were evaluated after the 4 year running period. CEVI received a very favourable evaluation and was among the six that had their mandate extended for another 3 years. Also in 2005 a new round of application for Centre of Excellence was opened by the Research Council of Europe. The original CEVI groups (Bakke, Bogen, Brandtzaeg, Sandlie, Sollid) have now applied together to become a Centre of Excellence on immune regulation (Centre

for Immune Regulation). This application is currently under evaluation. Examples of collaborations underway include that between Brandtzaeg's LIIPAT and the lab of Sollid on mucosal immunity for several years, especially on coeliac disease where Ludvig Sollid is a world authority. Similarly the Bogen, Sandlie and Gaudernack labs have joined forces in cancer vaccine work. The excellent scientific productivity of the thematic research group is demonstrated by the fact that some 50 original papers were published in 2005, CEVI groups are also developing commercial collaborations. Together with Oslo-based nasal drug delivery specialists OptiNose, Brandtzaeg's LIIPAT laboratory is a partner in NASALVAC, a Scandinavian consortium which aims to develop inexpensive nasal vaccines for HIV and TB for the developing world.

www.cevi.no

“Immunology underpins all medical research. The set-up here in Oslo is ideal for sharing of knowledge and rapid applications of new discoveries to different areas.”

Kjetil Taskén,
Professor of Immunology,
The University of Oslo.

COMPANIES

- *Commercial activity stimulated*

Oslo's immunology research base has stimulated the formation of several diagnostic companies as well as cancer vaccine specialists Gemvax featured in other sections. In addition two companies Lauras and Bionor Immuno are working on promising approaches to HIV treatment. Drawing on research at the Institute of Medical Biochemistry, University of Oslo, and at the Department of Clinical Immunology and Infectious Diseases at Rikshospitalet, LAURAS develops drugs for immunostimulating therapy in HIV/AIDS and other immune diseases. Such treatment would assist the immune system in driving out the HIV virus and is expected to lower the incidence of opportunistic infections in several immunodeficiencies. A single center phase I/II study on drugs affecting the immune response on T cell immune function was completed in 2002, with a longterm phase II study initiated in 2003.

www.lauras.no

Bionor Immuno aims to develop effective peptide based immunotherapies, against infectious diseases and currently focuses on HIV. Long term follow-up data recently published in AIDS on Bionor Immuno's lead candidate HIV-immunotherapy Vacc-4x showed patients experienced safe prolonged CART-free periods up to 3 years, and the duration of the CART-free periods was strongly related to the patient's immune responsiveness to Vacc-4x. The company, together with a consortium of European partners, has also just received an EU CRAFT grant for the development of a novel immunotherapy delivery device.

www.bionorimmuno.com

Although production is based in Tromsø, Biotec Pharmakon which produces a range of immunoregulating products based on beta glucans, runs widespread commercial and R&D activities in Oslo. Beta glucans are increasingly showing potential to improve immune response either when administered by themselves or as adjuvants to existing therapeutics, particularly in cancer.

www.biotec.no

"The close interaction between immunology groups here in Oslo has stimulated some world-class research which I believe has real commercial potential. "

Per Brandtzaeg,
Director of CEVI



CARDIOVASCULAR

PULSING WITH IDEAS

CARDIOVASCULAR

Oslo has a number of highly innovative cardiovascular diagnosis and treatment centers used as testbeds by both leading international and Norwegian companies - most recently for the exciting new field of Biomedical Wireless Sensors. Combined with the envied patient registry system, this expertise also continues to make the region increasingly popular for high quality clinical trials.

FROM IMAGING TO WIRELESS SENSORS

Researchers at Rikshospitalet's cardiovascular department were the world's first to undertake Doppler-based ultrasound examinations of patients' hearts. Further research into cardiac imaging continues, often in collaboration with companies such as Oslo-area GE Ving-Med Ultrasound (see below). General Electric has also selected an Oslo-based clinic as one of 12 institutions in Europe and the US to develop new keyhole surgery techniques and imagery. The unique Interventional Center at Rikshospitalet also acts as a testbed for new cardiovascular treatment techniques, including the pioneering Biomedical Wireless Sensor Network featured below. Another area of research in which Rikshospitalet scientists are in the forefront is the unravelling of the inflammatory network in cardiovascular disease, especially the importance for the development of the disease and as possible target for treatment.

BREAKTHROUGH CLINICAL TRIALS

A number of global pharmaceutical leaders, including MSD, GlaxoSmithKline and AstraZeneca, use Oslo as a

key location to develop and undertake clinical studies and explore new uses for their cardiovascular therapies. On the in vitro diagnostics front, Axis-Shield has developed a series of new cardiac markers such as homocysteine which have rapidly been taken into routine use worldwide.

CENTRE FOR HEART FAILURE DRIVES RESEARCH

Organised via the University of Oslo but with collaborating institutions throughout the Oslo region, the Center for Heart Failure Research operates more than forty projects in three main fields: inflammatory mediators and hormones in heart failure, changes in receptor function and intracellular signalling in heart failure and mechanisms of muscle dysfunction in heart failure. Funding to heart-related research will continue to grow as the grant to the Center for Heart Failure Research was extended until 2010, regional health authorities increase research expenditures and a growing number of projects gain EU funding. The Center for Heart Failure Research has also set up a Ph.D. school with roughly 30 students and separate funding from the Norwegian Heart Association.

THE INTERVENTIONAL CENTER

- looking far beyond surgery

Working on the premise of director Erik Fosse that there is no longer such a thing as pure surgery, the Interventional Centre at Rikshospitalet is an R&D center with a difference for image guided and minimal invasive surgery. Fosse and his team strive to develop tool boxes for other hospitals by mixing and matching the latest developments, most recently investigating the use of biosensors in image guidance. During such trials one of Oslo's key strengths comes into play. The excellent patient registries make it relatively simple to do high quality research and follow up, often with 100% participation. The Interventional Center also has a unique independent status, reporting direct to the hospital CEO and running its own theatres. The resulting freedom to

work in a true cross-disciplinary way has led to widespread international recognition. Currently the Center is a partner in several EU projects including ARISER for image guided surgery and CREDO for integrated biosensor networks. GE has an open collaboration agreement and there are also close contacts with Brigham Womens Hospital in Boston and CIMIT in Massachusetts General Hospital. Finally the Centre has invested its own IP in three spin-out companies – SimSurgery, for surgical training simulators, Alertis for pCO2 sensors to detect tissue ischaemia and Stomitap for new stoma care solutions.

www.ivs.no

“We have a freedom to innovate here quite unlike anywhere else. For high quality studies with near 100% follow-up guaranteed Oslo is unrivalled.”

Erik Fosse,
Director, Interventional Center.

“Good organization and leadership, a solid network of participating hospitals, and good funding have been the keys to a success in a series of seminal cardiovascular research trials in Oslo. The core teams are still in place and continue groundbreaking work.”

John Kjekshus ,
Professor of Cardiology, Rikshospitalet.



CLINICAL TRIALS

- three major landmarks

The quality and importance of Norwegian cardiovascular research is perhaps best illustrated by the fact that three of the landmark trials in modern medicine took place here. The Norwegian Timolol study was one of the first trials in clinical medicine to become a real cornerstone for treatment of patients in cardiology. The reason was a designed, randomized placebo controlled study which was organized and run by a Norwegian group led by Professor Terje Pedersen. The Timolol trial demonstrated for the first time and beyond doubt that patients with coronary heart disease benefited from betablocker treatment. This has since been the basic treatment for this disease.

ACE INHIBITORS

A further seminal clinical trial organized by John Kjekshus demonstrated the effect of blocking the Renin Angiotensin Aldosterone system by an ACE inhibitor, enalapril on survival among patients with severe heart failure. With 40% reduction in mortality after 6 months of treatment, the CONSENSUS trial changed the concept of treating heart failure and continues to be standard treatment of heart failure patients.

CHOLESTEROL LOWERING

The third landmark study was organized by Terje Pedersen as a large international trial to test the cholesterol hypothesis. When the trial was published in 1994 it demonstrated for the first time the effect of lowering cholesterol on cardiovascular mortality. After 5 years

of treatment simvastatin reduced cardiovascular mortality compared to placebo by 42%, without any effect on non-cardiovascular mortality.

CORE TEAMS STILL IN PLACE

These 3 studies still form the basis for treatment of cardiovascular diseases and many subsequent studies have confirmed and strengthened the importance of these results. According to John Kjekshus, their success depended on good organization and leadership, solid network of participating hospitals, and good funding. The core of the research group has been responsible for many more randomised clinical trials and have also contributed to the development of guidelines for these trials which are one of the most important scientific tools in clinical medicine .

WIRELESS LIFE SCIENCE TESTBED AND NETWORK

- the next big thing?

Centers such as the Rikshospitalet's Interventional Center in Oslo are already "hotspots" for new developments in wireless medical sensor technology. This has led Oslo to identify and prioritise Wireless Life Science as an area of high potential for growth, innovation and business development and become a major stakeholder in a new Norwegian-Swedish initiative - The Wireless Life Science Testbed and Network (WTN). With a long-term objective of reducing health costs and improving patient care, WTN aims to further stimulate the development, testing and verification as well as promotion of sensor networks. Other main stakeholders are MedCoast Scandinavia, MemsCap, Innovation Norway, Sintef and the West Götaland Region, along with strong

industry partners such as ACREO, Ericsson, IMEGO, Millicore, SimSurgery, Novosense and Novelda.

The initiative is facilitating the establishment of two testbeds in 2006 - one at the Intervention Center and another in Western Sweden, - and a network of projects and companies that will benefit from the infrastructure provided by the network and the testbeds. The Oslo testbed will be used by the first WTN project the Biomedical Wireless Sensor Network led by Eirik Næss-Ulseth of Novelda. They were recently granted NOK 3.8 million to develop wireless sensors for diabetes and cardiovascular related diseases and to test their integration.

DIAGNOSTICS AND IMAGING

OSLO'S LEADING BIOMEDICAL INDUSTRY SECTOR

While much of the Oslo region's life science potential currently lies in research strength and discoveries, the field of diagnostics here is a well-developed sector with large industrial players and constant innovations from a broad range of companies. To illustrate the diagnostics field in Oslo, this section will briefly present diagnostics companies active in the Oslo region: GE Health Care, Axis-Shield, Diagenic and Genpoint.

GE HEALTH CARE

- promoting Oslo as a world-class group asset

GE Healthcare's Medical Diagnostics operation is among the largest private life science/pharmaceutical employers in the Oslo region. Its 800 employees here work primarily on the research, development and manufacture of contrast media products for X-ray and magnetic resonance imaging (MRI). Products developed in the Oslo region like OmnipaqueTM, VisipaqueTM and OmniscanTM are on their way to the medical diagnostics "Hall of Fame".

GE Healthcare's Medical Diagnostics location in Oslo makes possible collaboration and co-operation with the Oslo Innovation Center, Rikshospitalet, Ullevål Hospital, the University of Oslo's medical faculty, R&D environments at Kjeller and with private and public institutes. The 350 researchers at the Oslo location cooperate with a network of imaging research centers, called ImanetTM, to use advanced imaging techniques such as PET to screen and test target molecules and develop specifically paired diagnostic and therapeutic radiopharmaceutical products.

GE Healthcare's activities in Oslo contribute to the group's global goals by creating leading brands in all imaging modalities, staying a lowest cost producer, maintaining a strong reputation and continuing a tradition of development and innovation. Overall the medical diagnostics part of GE Healthcare generated sales of NOK 4.1 billion from Norway in 2004, and invested NOK 452 million in R&D.

"Highly competent people and state of the art high-tech production lines enable GE Healthcare to meet the world's demand for top quality medical diagnostic products, GE Healthcare's Medical Diagnostics presence in Norway and Oslo is based on the availability of world

class medical diagnostics competence within the various fields of R&D and the world's largest and most cost efficient high-tech pharmaceutical manufacturing plant for basic contrast media substances at Lindesnes." says GE Healthcare's representative Finn Torgersen.

GE Healthcare has operations in Oslo, Kjeller, Horton and Lindesnes in Norway.
www.gehealthcare.com

AXIS-SHIELD

- making Oslo a hub for Point-of-Care (PoC) in vitro diagnostics

Axis-Shield employs roughly 65 scientists working in research and development in Oslo. These scientists contribute to a steady stream of innovations and roughly five patent applications per year. As Axis-Shield prepares to announce its first profitable year, the company works to get its AFINION Point-of-Care (PoC) center at the forefront of the PoC market.

Axis-Shield has grown as the result of well-timed discoveries, mergers and acquisitions of key technology, particularly Nycomed technology, which also practically doubled the company's Oslo-based research staff. Axis-Shield's R&D Director Erling Sundrehagen describes the Norwegian Research Council's early support as crucial to the company's success.

"Financially, and in terms of recruiting, we benefit by the presence of a strong cluster for diagnostics in Oslo. Here you have one of Europe's biggest cancer hospitals, and one of Europe's largest medical/chemical laboratories. Lastly, Oslo is a good place for scientists to do work on epidemiology, population studies and markers because the health registers are good," says Sundrehagen. Axis-Shield has developed the AfinionTM PoC center,

“The tradition of innovative diagnostics in Oslo has helped Axis-Shield become one of the leading invitro diagnostics providers worldwide.”

Ian Gilham,
Group Managing Director , Axis-Shield

which introduces a new concept in clinical diagnostics, allowing physicians to test for a wide number of blood parameters on-the-spot. The Anglo-Norwegian company hopes to stake out a strong position in the emerging PoC market with AfinionTM.

www.axis-shield.com

DIAGENIC

– paving the way to personalised medicine

Oslo-based DiaGenic ASA is an innovative biotechnology company established in 1998. It has been listed on the Oslo Stock Exchange from September 2004. The company has patents, pending and granted, for a method of identifying a gene expression signature characteristic for a specific disease.

The vision of DiaGenic is to provide easy-to-use diagnostics for several major devastating diseases using samples that are easily accessible. The company's gene expression technology aims to provide every disease with its unique fingerprint, at the earliest possible stage and with very high accuracy.

Company efforts are currently focused on the development of tests on commercially available test platforms for early diagnosis of breast cancer and Alzheimer's diseases using peripheral blood as the sample material.

www.diagenic.com

GENPOINT

– building a new frontline of defence against disease

Oslo's Genpoint AS was founded in November 1998 based on patent pending principles for DNA isolation and DNA based detection principles. The technologies were developed at the University of Oslo. Genpoint is an innovative biotech company specializing in microbial biology. Its products for clinical, food and environmental microbial diagnostics are based on cutting edge proprietary technologies.

The company develops and markets diagnostic kits for fast and easy detection of pathogenic and toxic microorganisms. The unique technology based on coated paramagnetic particles is capable of isolating virtually any bacteria from almost any matrix, and subsequently making DNA from the bacteria available for PCR-analysis. The specially designed particles are capable of binding both the microorganism and the DNA from the microorganism, and therefore allowing the whole process to take place in just one tube. This in turn makes the principle very easy to automate, and hence readily adaptable to large scale users.

www.genpoint.com

“The availability of worldclass medical diagnostics knowhow in our Oslo facility is one of the keys to GE's success worldwide.”

Finn Torgersen,
Director of Communications, GE Healthcare

BLUE AND GREEN BIOTECH

SAFEGUARDING RESOURCES

Blue and green biotech are key areas of growth for Oslo. This section details the potential of aquaculture and the way life sciences can pave the way to sustainable development of marine resources. Green refers primarily to world-leading research into the genetics of breeding in particular for Norwegian Red cattle and pigs.

ON THE CREST OF A NEW BLUE BIOTECH WAVE

Global aquaculture has been growing tremendously the last decades, now amounting to almost 40 million tons and a corresponding value of approx. 350 billion NOK (Source: FAO 2004). Norway, and especially the Oslo region, has played a pivotal role, both at academic and commercial levels, in changing global aquaculture premises and scenarios, especially in terms of industrialisation of major species. Its importance will inevitably grow since wild resources alone, no matter how well managed, cannot hope to meet demand. Expert opinion in Norway believes this challenge can be met by employing contemporary life science tools - combining genomics with the other new disciplines will pave the way ultimately for the culturally acceptable and sustainable exploitation of aquatic and marine resources.

PIONEERING FISH GENOMICS

Such optimism stems from the rapid development of fish genomics with genome sequence drafts for Pufferfish (*Fugu rubripes*) and model fish (e.g. Zebrafish, *Danio rerio*) and industrial fish (e.g. tilapia, salmonids, cod, shrimp etc) targeted for completion in the next 2-5 years. The resulting new biological insight will elicit a quantum leap in aquaculture by improving disease control systems, developing breeding and feeding regimes, optimising wild stock management regimes, and applying genetic traceability, molecular pathogen screening and other food safety actions. Furthermore such research is also paving the way for an exciting new "blue biotech wave" comprising bioprospecting, single cell-based production of substances and energy, e.g. micro algae based concerted production of food, feed, ingredients like astaxanthin and not least the ultimate fuel, hydrogen.

NEW MARELIFE REPORT MAPS THE FUTURE

Recently the Oslo region has taken major steps towards integrating and coordinating these activities further. As part of the "Capital City Project" stakeholders and key players from the life science cluster identified Marine

Life Sciences (MareLife) as a key area and established a project group. The objective of MareLife is to contribute to a long-term and strong biomarine sector with science, diversity and adaptability as major characteristics. MareLife will visualize strengths and opportunities of the Oslo region and foster collaborative networks between stakeholders of academia, commercialization and innovation. Further impetus and confidence has been helped by the fact that the industrial aquaculture sector has continued to bloom over the last year. In particular a substantial boost was given by the acquisition by Oslo-based Pan Fish (Pan Fish and Fjord Seafood) of the world's largest operator, Marine Harvest, making Pan Fish the largest international player.

VETERINARY SCHOOL LEADS IN FISH VACCINES

The Norwegian School of Veterinary Science co-operates closely with the Norwegian National Veterinary Institute to study fish health, fish sicknesses, epidemiology and aquamedicine. A spin-off from these entities was GenoMar, which is now among the world's leading life science enterprises specialising in brood stock enhancement of aquatic and marine species. Another major project in conjunction with CIGENE involving the mapping and study of the salmonoid genome (www.salmongenome.no) has drawn significant attention from Canada and Iceland. www.veths.no

ÅS FORMS MAJOR HUB

The Ås community combines research groups within the University of Life Science and the AKVAFORSK research institute, which specialise in breeding programmes, fish feed, and product quality. The Aquaculture Protein Centre (www.apc-coe.no) is a national center of research excellence at Ås, but also involves research groups at the Norwegian School of Veterinary Science and throughout the country. Its research into PAM (Protein and amino acid metabolism), GH (gut health) and FIP (feed ingredients and processing) is funded by NOK 100 million in grants annually from 2003 to 2007.

BREEDING PROGRAMMES WITH PERSUASIVE RESULTS

Since 1960, Akvaforsk has been one of the world's leading research institutions in developing selective breeding programmes for aquaculture species. Its research into breeding and genetics, product quality and marine species is at the top of the field, and the institution with almost 100 staff has carried out groundbreaking work with 26 species in 35 different countries. Akvaforsk is co-located with the University of Life Sciences in Ås, Norway, and co-operates closely with research teams at the Aquaculture Protein Centre and CIGENE, among others. (www.akvaforsk.no). Akvaforsk established the subsidiary Akvaforsk Genetics Center in 1999 to administer commercial breeding programmes on a worldwide basis. The combination of Akvaforsk's knowledge and the genetic center's project work has had phenomenal results; A breeding programme for Atlantic salmon resulted in potential savings worldwide of USD 200 million in feed costs, for world production of one million tonnes. A similar programme on tilapia led to a growth rate in the target population almost two times the original after only five generations. AFGC is also a leading provider of applied genetic improvement services to aquaculture industries worldwide, serving large-scale selective breeding programs for a series of species. www.afgc.no

HARVESTING "NEW" FIELDS OF BIOPROSPECTING AND BIOENERGY

The University of Oslo is a world leader in the studies of marine ecosystems, and is pursuing fields like bioprospecting and bioenergy. Furthermore, the Centre for Ecological and Evolutionary Synthesis (CEES) at UiO chairs an international network called MarEGene. The MarEGene network includes several marine research units around Skagerrak, and their collaboration projects target bio resources with by far the largest potential, such as marine wild stocks and ecosystems. CEES also has strong interests in the North Sea, Norwegian Sea and Barents Sea, with the objective of studying and mapping population structures and dynamics as well as multi-species interplay through the integration of several scientific fields and technologies like ecology, molecular genetics and population biology.

www.uio.no

The Oslo Region is also internationally in the forefront of many blue and green emerging fields through both academia and biotech companies:

Marine genomics: CIGENE and Norwegian University of Veterinary Sciences through the cGRASP project (sequencing the salmon genome)

Breeding and genetic enhancement systems in a series of aquatic species (AKVAFORSK and GenoMar)

Molecular vaccinology and disease control systems (Pharmaq, Norwegian School of Veterinary Sciences through FishVac in collaboration with Intervet)

Genetic traceability (GenoMar, AKVAFORSK and CIGENE)

Microalgae and hydrogen technology (NIVA)

Nutrition, novel feed and feed ingredients (Aquatic Protein Center, University of Life Science and Norwegian School of Veterinary Sciences)

Bioprospecting (Biotech Pharmacon)



PHOTO: Institute of Marine Research/Havforskningsstasjonen Austevoll

GREEN BIOTECH

UNTAINTED LIVESTOCK IN DEMAND

Oslo is also a leading center for animal and plant life sciences. Norwegian farmers have traditionally been extremely concerned about animal welfare and successfully resisted the pressures over the last 50 years to increase yields at all costs. Furthermore animal health records were kept with the same diligence as human. Only vets are allowed to prescribe antibiotics and this has resulted in unique and rich data banks of information on over 3 million animals. There has also been a systematic storage of semen and tissue samples from breeding stock creating in effect animal biobanks. This unique combination of information is now being mined for in-depth genetic studies of low hereditary traits in cattle such as mastitis that are difficult to improve by traditional breeding programmes. Similar programmes are in place for swine.

The biobanks are housed in Hamar, north of Oslo, while genetic research is primarily performed at the Department of Animal Science of the University of Life Science in Ås, taking advantage of the analytical facilities offered by CIGENE. Other leading Oslo-based resources are the Norwegian Zoonosis Center and the Norwegian School of Veterinary Science. Commercialisation is through a series of world leading companies.

NORWEGIAN RED CATTLE SPURRING HEALTHIER LIVESTOCK REVOLUTION

GENO is the farmers' co-operative owned and managed by Norwegian dairy farmers which initiated the collection of samples. Their main aim is to breed the Norwegian Red, a high producing dairy breed, characterized by a high genetic resistance to mastitis and good fertility. GENO directs research into these genetic traits and has successfully introduced breeding programmes in Europe and the US. They are also involved in a joint venture with Aquagen called Cryogenics which specialises in freezing salmon semen genes, a technique they are looking to apply to other breeds.

www.geno.no, www.cryogenics.no

PIG GENETIC EXPERTISE EXPORTED

In addition to this, the Norwegian pig health situation is among the best in the world. The country is free from Swine fever, Foot and mouth disease, Aujeszky's disease, Rabies, Transmissible gastro-enteritis (TGE), Swine Influenza, Porcine respiratory and reproductive syndrome (PRRS) and all other serious contagious pig diseases. Norsvinn, also originally a farmers' co-operative monitors closely the phenotypic development of Norwegian pigs for a wide range of traits, and applies the resulting knowledge to new breeding programmes. Other R&D projects include Genetics of Boar Taint, i

identifying genes influencing defects in Norsvinn Landrace, genome-wide linkage analysis of inguinal hernia in pigs and fine mapping of QTL for intra muscular fat (IMF). Norsvinn USA also recently announced the signing of Genetic Material and Research and Development agreements for North American markets.

www.norsvinn.no

Graminor plays a similar role in plant breeding company looking at genetic traits of breeding cereals, forage crops, potatoes, fruit and berries.

CIGENE INTEGRATES BLUE AND GREEN GENETICS WORK

The CIGENE group at the University of Life Science at Ås is a functional genomics center that aims to contribute to a deep causal understanding of complex genetic characters in fish, plants and animals for scientific and commercial exploitation based on an integrative genetics approach. As a core facility under the Norwegian Functional Genomics Programme (FUGE), CIGENE is responsible for providing a national service for detection, typing and interpretation of SNPs (Single Nucleotide Polymorphisms), and for systems-oriented computational biology. This in turn provides the tools for researchers and companies involved in Norway and Oslo's blue and green biotech revolution. Taking just a few examples, CIGENE has already developed a range of advanced analytical methods including new haplotyping and QTL fine mapping techniques. These and others are being successfully applied in a number of projects such as the creation of a high-density SNP-map for chromosome 6 in cattle, detection, validation of >2000 genomewide SNPs on Atlantic salmon, detailed mapping of a promising QTL in cattle, and work on salmon filet colour as a proof of principle trait concerning integration of the whole CIGENE toolbox. This group is a world leader in research into fish genomes, and cooperates closely with a number of international research communities in Canada, USA, UK and France.

www.cigene.no

"We are experiencing a paradigm shift in aquaculture. Norway and especially the Oslo region are playing a pivotal role contributing with science and commercial innovations, changing the global aquaculture premises and scenarios."

Professor Øystein Lie,
Genomar.

CLINICAL TRIALS

A POSITIVE VERDICT

High quality clinical trials are a speciality of the Oslo region due to excellent patient recruitment and retention. Leading pharmaceutical companies from AstraZeneca to Roche have taken advantage of this for cardiovascular and cancer treatments in particular

EXCELLENT PATIENT RECRUITMENT AND RETENTION

While low costs drive clinical research investments in Asia and South America for big pharma, other countries have to compete on quality. Norway and the Oslo region in particular are well placed to do this for a variety of reasons. The Health Registry system and concentration of expertise in large centralised hospitals simplifies patient recruitment and follow-up. Furthermore, there is a generally positive approach to medical advances, and a relatively high uptake of new treatments. As a result some 203 clinical trials were initiated in Norway in 2003 of which 110 were financed by international pharmaceutical companies. GSK, Roche, Pfizer and MSD all have interests. Currently some 11 Norwegian drug discovery companies also have product candidates in clinical development. Recognising the growing importance of the sector, a new public clinical research programme starts in 2006.

ASTRAZENECA'S CLINICAL RESEARCH IN NORWAY - OUTPERFORMING ALL OTHER UNITS

AstraZeneca employs 250 people in Norway and, currently, is running 35 clinical trials covering 3000 patients and 317 research centers here. It is located in Oslo, and most of its research budget is spent in the Oslo region and at its large hospitals. An annual performance report produced by AstraZeneca provides as accurate a picture as possible of the company's research efforts and – in essence – what bang AstraZeneca is getting for its research buck. Not surprisingly, AstraZeneca's units in Asia and the Americas (excluding the USA) are lowest in total costs per clinical research unit – a composite with weighting for a trial's complexity and size. What may surprise many people familiar with the clinical research industry is this: In 2004, Norway came in a clear first when measuring clinical research units per employee. In addition, AstraZeneca in Norway managed to lead another important parameter: measuring how rapidly patients are recruited into a trial. Finally, internal audits and external audits (by the US Food and Drug Administration, among others) resulted in very

few comments – another sign of quality operation. Since most developed Western countries cannot compete with Asia and South America on overall costs for salaried staff, these high-cost countries have to compete for studies based upon the quality of their clinical research performance. They angle for complicated trials with tight margins, metaphorically speaking. In this race, AstraZeneca in Norway is a leader within the global AstraZeneca structure.

AN IDEAL COUNTRY

While this performance and efficiency certainly attest to effective management and a strong organisation in Norway, AstraZeneca Norway, and global vice president clinical development Henrik Lund gives the biomedical establishment in Norway and Oslo much of the credit. "Norway shows the fastest implementation of new pharmaceutical therapies of any country in Scandinavia. It has a strong public health service, extremely proficient physicians, a population friendly to clinical trials and good public health records. Combine these aspects with short approval times with regulatory agencies and a tradition for large pharmaceutical trials like beta blockers and statins, and the result is an ideal country to execute clinical trials."

"Oslo and Norway show the fastest implementation of new pharmaceutical therapies of any country in Scandinavia and Oslo is an ideal location to execute clinical trials."

Henrik Lund,
global vice president Clinical development,
AstraZeneca

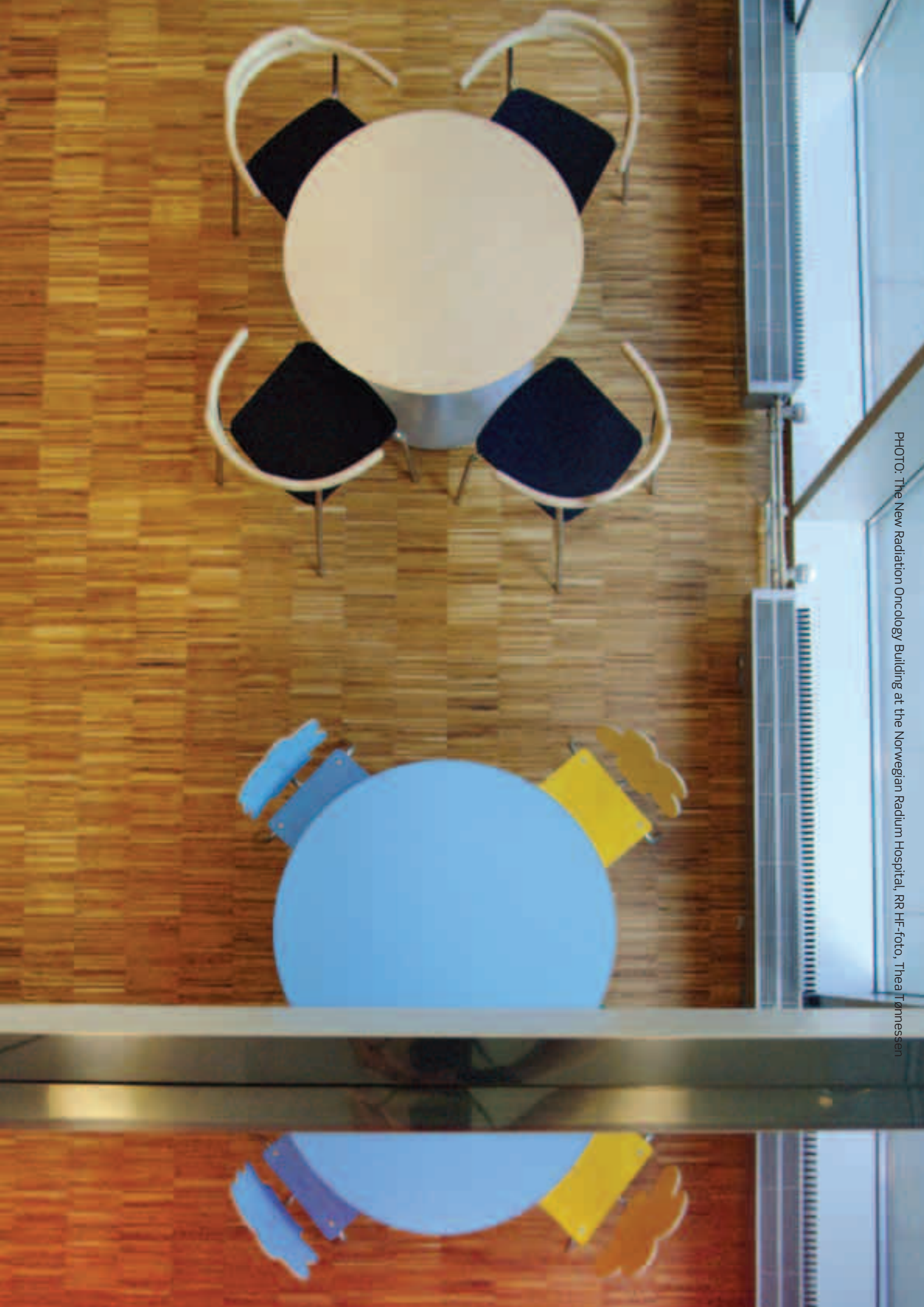


PHOTO: The New Radiation Oncology Building at the Norwegian Radium Hospital, RR HF-foto, Thea Tønnessen

ATTRACTIVE BUSINESS ENVIRONMENT

The Oslo region regularly features in international surveys as one of the most attractive places to live and work. This section details the basic facts and figures along with background on the strong collaborative outlook of Norwegian research and business – not just within the county but also with the greater Nordic region, Europe and the US. Although not mentioned here, China and the Far East are also growing partners. Finally there is a list of useful organisations for further background.

A TRADITION OF INDUSTRIAL CROSS-FERTILISATION

Norway is a relatively small and cohesive country with a history of collaboration between different industry clusters. Innovative co-operation between life sciences and other industry clusters is especially evident in the “merger” between life science and ICT.

LEADING THE WAY IN TELEMEDICINE

One area of extensive national collaboration is within telemedicine, which has many possible applications. For instance, simple devices may soon help children with diabetes and their families by allowing the family to receive the child’s blood sugar level readings by an SMS to their mobile telephone. The Norwegian Centre for Telemedicine is a national resources centre for telemedicine in Norway, and – since 2002 – the first World Health Organization Collaborating Center for Telemedicine. There are several other organisations also concerned with aspects of telemedicine such as the KITH centre of competence in information and communication technology in health care, KoKom – a national

centre for emergency health care and communication strategy and the Interventional centre at Rikshospitalet. Another example of national and international cooperation, where the Interventional centre is playing an important role, is the Wireless Life Science Testbed and Network project as displayed in the cardiovascular section.

INTEGRATING GENOMICS RESEARCH ACROSS SECTORS

Other areas of collaboration are gene-mapping and functional genomics. The Norwegian Computing Centre, one of Europe’s largest and most competent groups within applied statistics and statistical-mathematical modelling, has identified areas where their statistical competence is vital in transforming huge amounts of functional genomics data into important pieces of knowledge. Other Norwegian companies and research centres such as the Norwegian University of Life Sciences and Fast Search and Transfer are developing competence and technology that will be valuable for life science research in the future.



PHOTO: Gunnar Strøm / visitOSLO

AREA:	5 370 sq. km
POPULATION:	1 039 536
DENSITY:	1 186 residents per sq. km in Oslo 194 per sq. km in Oslo/Akershus
AGE STRUCTURE:	25 % < 19 31 % 20-39 33 % 40-66 11 % 67 <
NO. OF STUDENTS:	60 000
GDP/CAPITA:	NOK 391 399 in 2003 (45 percent above EU average)
LABOUR FORCE:	585 939 in 2005 (excl. self-employed workers)
EMPLOYMENT:	87 % in private/public service sector (incl. R&D, financial and high-tech related industries) 13 % in manufacturing (incl. high-tech manufacturing), construction and process industries
UNEMPLOYMENT:	2.8 % (August 2006)
COMPANIES:	100,627 (2005, up more than 10 000 from 2002)
CORPORATE TAX:	28 %
R&D:	2 universities, 3 colleges and 26 specialised colleges, 75 R&D institutions (including universities and research-based colleges), 4 science parks, 6 Centres of Excellence and 5 Centres for Research-based Innovation, i.e. close to 50 % of all R&D in Norway is located to the Oslo region
TAX DEDUCTION:	R&D expenses in all enterprises, which are eligible for Norwegian taxation (www.skattefunn.no)

NORWAY AND THE NORDIC CONNECTION

STRENGTHENING NORDIC LINKS AT ALL LEVELS

Norway and Oslo have cooperated with other countries and regions for many years. The Nordic countries have collaborated for more than forty years to foster market integration and innovation across the borders of the Nordic states. One of the more recent cooperative efforts is MedCoast Scandinavia, a Swedish-Norwegian networking organisation, founded to further strengthen and develop the biomedical sector in the Göteborg-Oslo (GO) region. MedCoast Scandinavia acts as a catalyst for collaboration between scientists, businesses and the public sector, and works to promote entrepreneurship and the commercialisation of innovative ideas. MedCoast Scandinavia's vision is that Gothenburg-Oslo will become a major biomedicine region connected to Medicon Valley, a life sciences cooperation covering Copenhagen in Denmark and southern Sweden from Malmö and up to the Stockholm region. www.medcoast.org

THE SCANDINAVIAN LIFE SCIENCE DATABASE

To further strengthen Scandinavia as a world-leading region in life science/biomedicine, the leading regional actors in Scandinavia are now joining forces. The Scandinavian Life Science Database - a comprehensive non-

profit database of Scandinavian companies active in the Life Science area - was initiated in 2004 by some of the leading actors in Scandinavia. Over 1000 companies from Norway, Denmark and Sweden with a focus on life science have joined the database. The website www.scandinavianlifescience.org features this valuable, searchable database.

SCANBALT REACHES EVEN FURTHER

The Nordic countries have lately extended their "commitments of collaboration" to include the Baltic states. ScanBalt, a partner in the Scandinavian Life Science Database, promotes and works for the development of the ScanBalt BioRegion as a globally competitive metabioregion including 11 countries, 67 universities, 85 million people and 800 biotech companies. www.scanbalt.org

The Nordic Innovation Centre, another publicly financed cooperation between the Nordic countries, funds projects within life sciences, mainly with partners from the Nordic countries. Russian and Baltic partners are also included in some contexts. The Nordic Innovation Centre's overall goal is to improve the Nordic countries' innovation policies.



PHOTO: Per A. Poulsen / VISITOSLO

NORWAY INTERNATIONALLY

A COMMITMENT TO PARTICIPATE

In its most recent white paper on research, the Norwegian Ministry of Education and Research sets its focus on three pillars: basic research, applied research and internationalization. The report says: *“First of all, internationalization will be a comprehensive perspective for our research policy. International participation will be prioritized in the distribution of resources for research.”*

CREATING CENTERS OF EXCELLENCE

Norway and Norwegian institutions co-operate widely with international researchers through Nordic initiatives, EU research programmes and extensive bilateral agreements with countries in North America (USA and Canada), Asia (Japan and China) and elsewhere. Through the Nordic Council of Ministers, Norway is committed to making the Nordic region a world leader in research and innovation. NordForsk, a pan-Nordic and Baltic organization pushing research and research training, will invest NOK 60-70 million in 2005. Oslo-based institutions are already playing key roles in two Nordic centers of excellence in molecular medicine. In addition, a vast amount of more informal information exchange between Nordic institutions happens at the organisational level in Oslo's universities and hospitals, through boards, scientific panels and visits.

ACTIVE IN EU FRAMEWORK PROGRAMS AND INTEGRATION

Norway partakes actively in the EU's research framework programs. As of late 2005, 28 per cent of Norwegian applications to the EU's sixth framework programme were successful, compared to an 18 per cent average across the EU. Norway partook in 11 per cent of all EU projects (576), with over 3000 Norwegian researchers and research financing for more than NOK 1.5 billion. Norway is active within progress towards a pan-European research organisation, the European Research Area. Norway has a number of projects in the EU's EUREKA programme, COST and high-quality research initiatives like the European Molecular Biology Laboratory (EMBL).

LOOKING TO THE US

In 2005, the Norwegian Ministry for Education and Research set aside NOK 10 million specifically to promote a government strategy (created by 11 ministries in 2004) for increased research and technology co-operation with the USA and Canada. The strategy has three parts: long-term escalation of R&D collaboration, enhancement of the quality of Norwegian research and increased knowledge-based economic development in Norway. This will build on an existing trend: from 1981 to 2002, the number of scientific articles produced by researchers located in Norway in conjunction with researchers in the USA and/or Canada grew from 117 to 826. This includes Norwegian companies like Nycomed Imaging (now owned by General Electric) with 56 and Dynal Biotech (now owned by Invitrogen) with 4. In addition, patent applications in the USA with at least one Norwegian applicant spiked in the 90s and after 2000.

EU BONE MASS RESEARCH, SMEs AND UNIVERSITY HOSPITAL

An EU sixth framework programme initiative called “SMEs go Life Sciences” has as its goal to increase the participation of small- and medium-sized EU businesses in biotechnology research projects in Europe. As of late 2005, Norway played a coordinator role in three projects within SMEs go Life Sciences. One of these projects, “Molecular mechanisms of bone homeostasis”, is coordinated by the Department of Clinical Biochemistry at the Ullevål University Hospital in Oslo. The project has 8 participants, duration of 36 months, a budget of EUR 2 million and a long-term goal of reducing the impact of osteoporosis in Europe. In a steadily aging Europe, a project like this can lead to better, longer lives and real commercial potential.

TECHNOLOGY TRANSFER OFFICES

Bio Medical Innovation AS	www.bmioslo.no
Bioparken	www.bioparken.no
Birkeland Innovation	www.birkelandinnovasjon.no
Medinnova	www.medinnova.no
Oslo Innovation Center	www.forskningsparken.no
The Norwegian Radium Hospital Research Foundation	www.radforsk.no

UNIVERSITIES AND R&D

Akershus University Hospital	www.ahus.no
AKVAFORSK	www.akvaforsk.no
Bioforsk	www.bioforsk.no
MATFORSK	www.matforsk.no
Norwegian Agricultural Economics Research Institute	www.nilf.no
Norwegian Institute for Air Research's	www.nilu.no
Norwegian Institute for Water Research	www.niva.no
Norwegian University of Life Sciences	www.umb.no
Rikshospitalet University Hospital	www.rikshospitalet.no
SINTEF Health Research	www.sintef.no
The Biotechnology Centre of Oslo	www.biotek.uio.no
The Centre for Ecological and Evolutionary Synthesis	www.cees.no
The Centre for Molecular Biology and Neuroscience	www.cmbn.no
The Interventional Centre	www.ivs.no
The National Veterinary Institute	www.vetinst.no
The Norwegian Food Safety Authority	www.mattilsynet.no
The Norwegian Radium Hospital	radium.no
The Norwegian School of Veterinary Science	www.veths.no
The Norwegian Zoonosis Centre	www.vetinst.no/zoo
The University of Oslo	www.uio.no
Ullevaal University Hospital	www.ullevaal.no

NETWORKS AND INDUSTRY

Innomed	www.innomed.org
MedCoast Scandinavia	www.medcoast.org
NorBioBase	www.norbiobase.no
Norwegian Biochemical Society	www.biokjemisk.com
Norwegian Bioindustry Association	www.biotekforum.no
Oslo Bio	www.oslo.teknopol.no
The Scandinavian Life Science database	www.scandinavianlifescience.org

PUBLIC ORGANISATIONS

Innovation Norway	www.innovasjon norge.no
The Norwegian Biotechnology Advisory	www.bion.no
The Norwegian Food Safety Authority (NFSA)	www.mattilsynet.no
The Research Council of Norway (NFR)	www.forskningsradet.no



PHOTO: The New Radiation Oncology Building at the Norwegian Radium Hospital, RR HF-foto, Thea Tønnessen

osloteknopol

– your key to the Oslo region

Oslo Teknopol aims to promote Norway's capital region in order to attract foreign investments and talent, and to facilitate innovation and growth in the Oslo region's strongest knowledge-based clusters. Oslo Teknopol works closely with leading players from business, research and higher education, as well as national and local government agencies. Established by the City of Oslo and Akershus County Council, Oslo Teknopol is a non-profit regional development agency. Foreign companies can obtain free assistance and information about business conditions and opportunities within the following clusters in the Oslo region:

- Maritime
- Energy and environmental technology
- Information and communication technology
- Life science
- Culture



Oslo Bio is a collaborative network of stakeholders from the life science cluster. Oslo Bio aims to strengthen the cluster and contribute to long term growth through marketing, initiating and facilitating development projects, and international collaboration. Oslo Teknopol act as the secretariat for Oslo Bio.

www.oslo.teknopol.no



Innovation Norway is a state owned company aiming at nationwide industrial development by contributing towards innovation, internationalisation and promotion. The core group of clients are Norwegian companies, predominantly SMEs. Innovation Norway has offices in all Norwegian counties and in more than 30 countries world-wide. Head office is located in Oslo.

www.innovasjon Norge.no

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