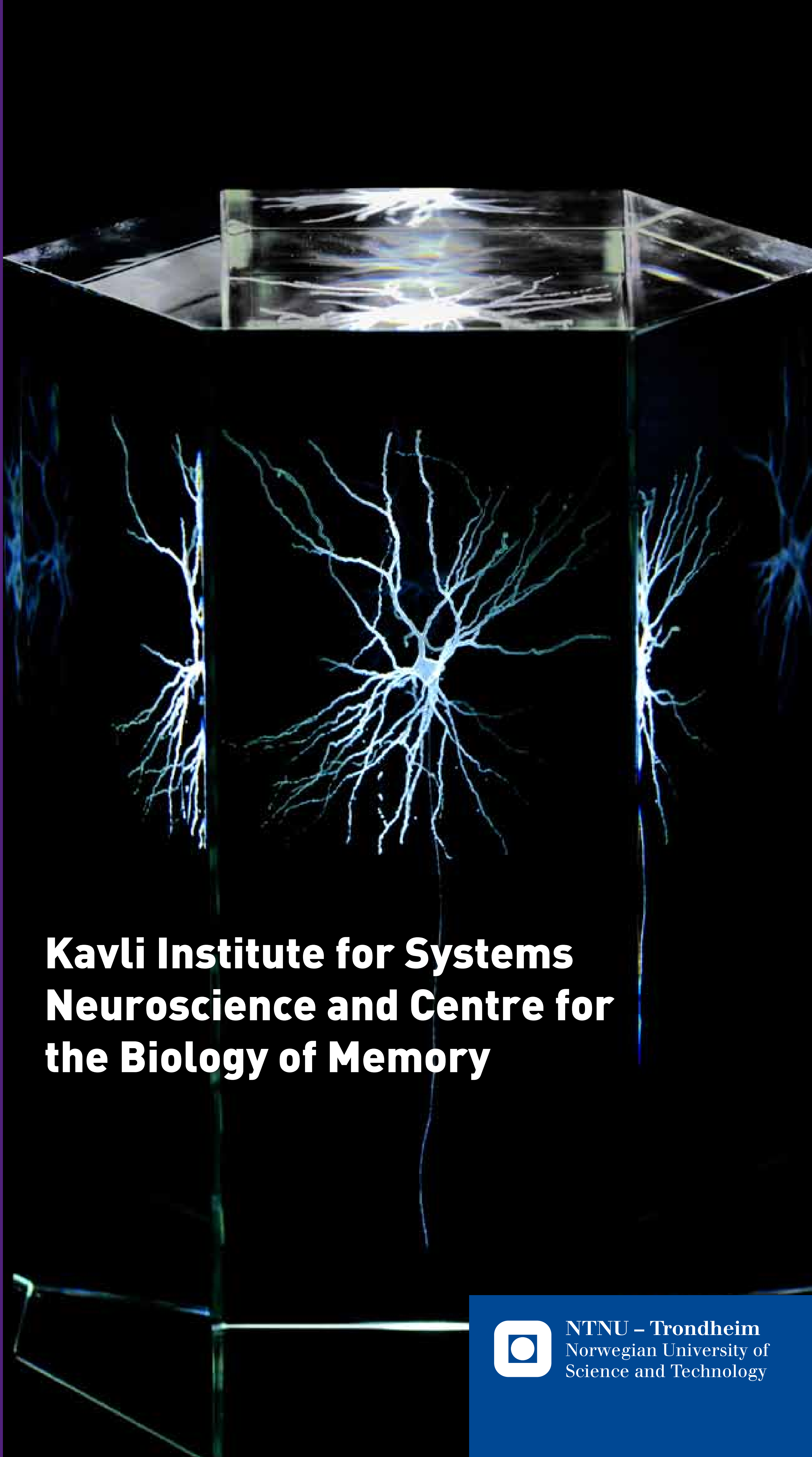
Annual report 2010



Kavli Institute for Systems Neuroscience and Centre for the Biology of Memory

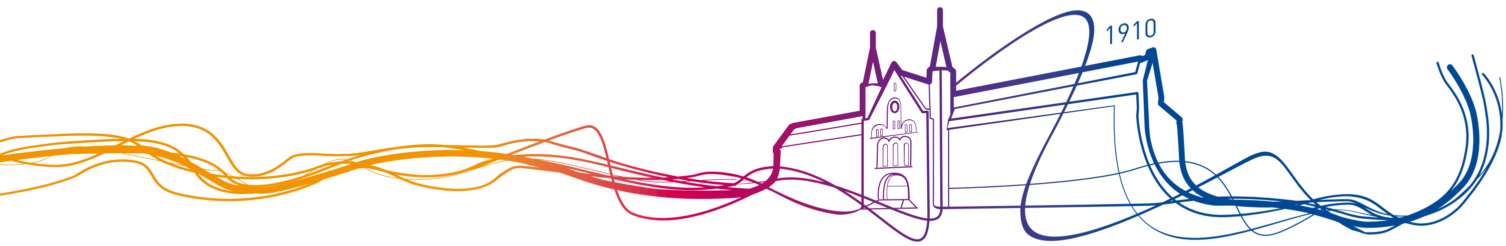
NTNU – Trondheim
Norwegian University of Science and Technology

Annual report 2010

Kavli Institute for Systems Neuroscience and Centre for the Biology of Memory

The staff at KI/CBM March 2011. *(Photo: Ned Alley)*

Front page: The cornerstone laid by Minister of Research and Higher Education Tora Aasland for the new Norwegian Brain Centre in Trondheim is a crystal with a reconstruction of a real brain cell from a rat.



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CONTENT

KI / CBM – a brief history

The Centre for the Biology of Memory (CBM) was established at the Norwegian University of Science and Technology (NTNU) in 2002 as a Centre of Excellence (CoE) with funding for ten years from the Research Council of Norway.

In 2007, the Norwegian-American physicist, businessman, billionaire and philanthropist Fred Kavli selected CBM as one of 15 prestigious Kavli Institutes. The CBM is the only Norwegian institute to be thus honoured to date. The appointment means the department gets about NOK 7 million in annual support from the Kavli Foundation for the foreseeable future, in addition to tremendous international recognition.

As a result of its history, the centre now has two names: the Kavli Institute for Systems Neuroscience and the Centre for the Biology of Memory (KI / CBM). After 2012, when the CoE period expires, the centre will "only" be the Kavli Institute for Systems Neuroscience. The Norwegian Ministry of Education and Research has indicated a willingness to continue with funding after the CoE period ends.

NTNU strengthens, unifies and sharpens brain research

"I am proud of what you have achieved and can promise that the government will also support this effort in the future," said Minister of Research and Higher Education Tora Aasland, as she laid the cornerstone for the Norwegian Brain Centre in Trondheim on 10 January 2011.

The Norwegian University of Science and Technology (NTNU), home to the KI/CBM, decided in March 2010 to invest NOK 42 million in the establishment of the Norwegian Brain Centre (NorBC), which aims to become the world's largest laboratories for the measurement of electrical activity in neural networks (large groups of brain cells).

The centre is a continuation of NTNU's long-term focus on brain research with the KI/CBM at the forefront. When Minister Aasland laid the cornerstone in January 2011 with a guarantee of further government financing, the message was well received. While the minister did not promise any specific amount, this was interpreted positively because it leaves room for negotiations about the size of the contribution.

"Here in Trondheim you have created a research environment that excels internationally. I hope the new centre will continue to evolve and find new answers that can benefit society," said Minister Aasland. The cornerstone she laid is a crystal with a reconstruction of a real brain cell from a rat.

Increase in space, standards upgraded

The KI /CBM is currently located in a part of NTNU's Medical Technical Research Centre, but in 2010, when a number of other research groups moved to the new university hospital at St. Olavs Hospital, a good deal of space became free. The expansion plans call for NorBC's area to expand by nearly tenfold to well over four thousand square meters, while at the same time the overall standard will be upgraded.

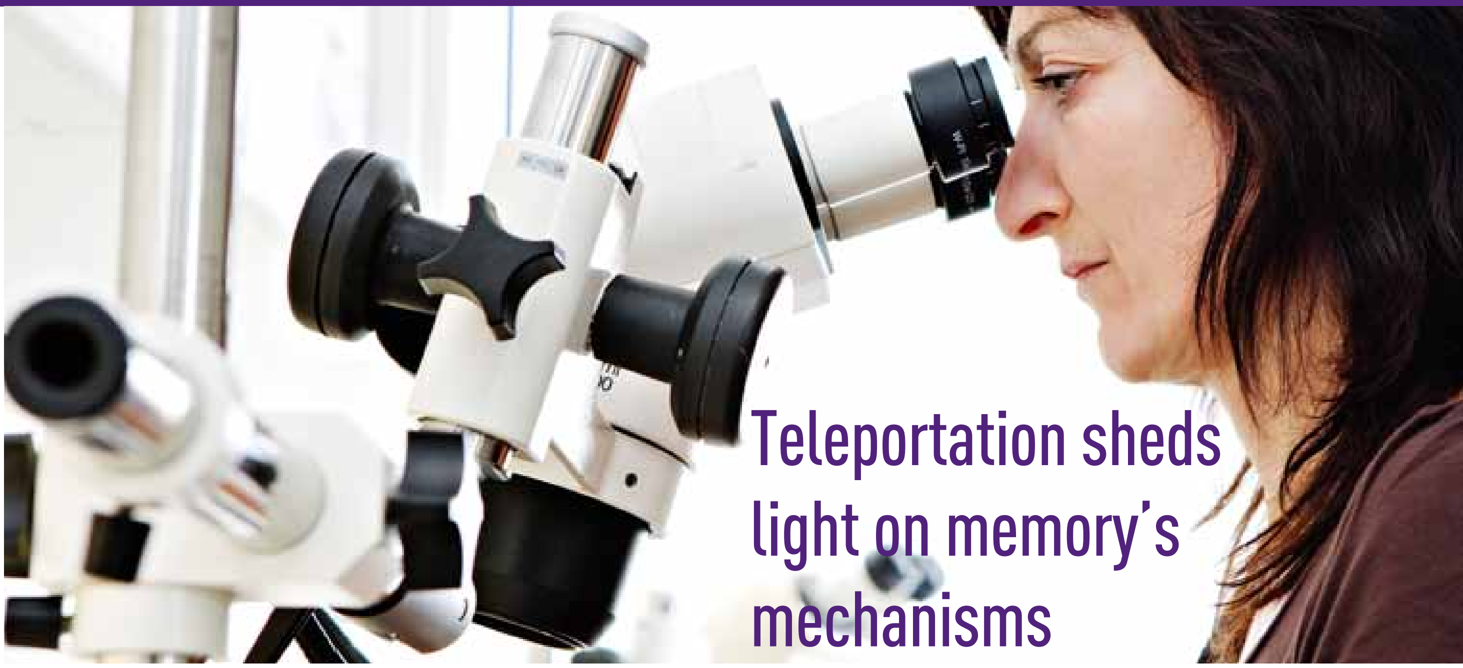
"The Ministry has decided to ensure stable and sound conditions for this outstanding research in the years ahead," said Minister Tora Aasland, as she laid the cornerstone for Norwegian Brain Centre in Trondheim. Professor Menno Witter and NTNU Rector Torbjørn Digernes were happy to hear the news. (Photo: Raymond Skjerpeng, KI/CBM)

"We will now create a centre that will cover a wide range of methodological approaches to understanding how the brain's networks function. This can be anything from theoretical studies in physics and the microscopic study of nerve cell connections, to imaging studies of the brain at work. The brain is such a big mystery that there is a need for multiple approaches to crack its secrets," said Professor Edvard Moser, NorBC director. The centre will accommodate students and scholars from home and abroad who need to learn about the latest in brain technology.

"The intention is to build a centre that will help ensure that we retain our position as a world leader in research on the brain's sense of place and memory. Among other things, it is important to strengthen our effort with new research groups and new scientific equipment," commented NTNU Faculty of Medicine Dean Stig Slørdahl on his blog.

"We want to further strengthen, unify and sharpen our efforts at the forefront of brain research with the Norwegian Brain Centre. The centre will help to put Trondheim and Norway on the international research map," said NTNU Rector Torbjørn Digernes to St. Olavs Hospital's internal news service.

In addition to NTNU's contribution, the research activities at NorBC will be financed with contributions from the Research Council of Norway, the European Research Council (ERC), the Kavli Foundation and the EU's Framework Programme.



Teleportation sheds light on memory's mechanisms

Professor May-Britt Moser was one of seven Norwegian scientists who received the ERC Advanced Investigators Grant in 2010. Her husband, Professor Edvard Moser, received a similar grant in 2008. *(Photo: Geir Mogen)*

Professor May-Britt Moser was awarded an Advanced Investigators Grant from the European Research Council (ERC) in November 2010. The funding will be used for a project which in part examines the episodic mechanisms of memory by getting rats to feel like they have been teleported.

The ERC Advanced Grant is considered international recognition at the highest level, and will finance May-Britt Moser's projects with 2.5 million euros over the next five years. Professor Moser will also receive additional financial support from NTNU, which together will give the Kavli Institute an additional NOK 5 million (0.62M€) extra per year until 2015. The grant will fund a broad research programme, ranging from the basic phenomenology of the transition between hippocampal representations, to the role of gamma-oscillations, thalamic activity and anatomy and development.

May-Britt Moser and her colleagues are currently developing a new method in the lab where they will determine how environments and experiences are represented in a short-term time domain and how groups of cells (ensembles) involved in one representation fade into those associated with another.

Simulated teleportation

"When you can distinguish one Christmas Eve from another in your memory, it is because the different memories are encoded in different networks of neurons in the brain. But the memories of the various Christmas evenings also have many common features and are stored in the same area of the brain, and you can 'switch' quite quickly between the memories," Moser explains.

This is much the same for a rat in the laboratory that has memories of looking for food in two different rooms. "The method we are developing can get rats to believe that they have been moved from one room to another in milliseconds, without actually moving. The rats will have the feeling of being teleported, or perhaps that they are located in two places at once," she says.

The method was not designed to teleport or confuse rats, but because Kavli scientists and the European Research Council hope that the research will point the way to a better understanding of the mechanisms responsible for the retrieval of episodic memory. If we understand memory better, it may be possible to develop new treatments for people suffering from memory loss.

Fourteen ERC grants to Norway

Moser's award in 2010 means that a total of 14 Norwegian scientists have been honoured with the ERC's Advanced Investigators Grant, which is linked to the EU's 7 Framework Programme for research. Edvard Moser was one of two Norwegian scientists who received an ERC Advanced Grant at the first ceremony in 2008. In 2009, the prestigious grant was awarded to five Norwegian researchers. There were 37 Norwegian applications for the third application round in 2010, and May-Britt Moser was one of the seven who was selected for funding in the final round.

About Rosamund Langston

Rosamund Langston came to KI/CBM in June 2007 as a postdoctoral researcher. She published her first article in Science magazine, on the role of the hippocampus in event memory in the rat, during her PhD in 2007. Her PhD thesis earned her the British Neuroscience Association Postgraduate Prize. The article in Science in 2010 was the result of three years work as a Bettencourt Postdoctoral Fellow in Trondheim.

Rats are born navigators

New results from the Kavli Institute in June 2010 indicate that the rat brain comes hard-wired with working navigational neurons. In other words, rats seem to be equipped with an innate sense of direction, explains Dr Rosamund Langston.

Rosamund Langston's work with baby rats shows that the brain comes hard-wired with an innate sense of direction.

Dr Langston and her colleagues in the Moser research group at the KI/CBM wanted to know how the brain maps place and space when an animal navigates independently for the first time. The research team implanted miniature sensors in very young rat pups, which enabled them to record neural activity when the rat pups opened their eyes and left the nest for the first time to explore a new environment. The group's results created a great deal of interest when they were published in Science magazine in June, 2010. If we learn more about how rat brains work, we will also learn more about human brains.

Baby rats open their eyes and begin exploring by about 15 days after birth. The researchers discovered that the rats had working navigational neurons right from the beginning, but they were also able to see the order in which the cells matured. The first to mature were the head-direction cells. "These neurons are exactly what they sound like – they tell the animal which direction it is facing, like an inertia-based compass. The head-direction cells in the rat pups were basically adult-like right from the beginning," Langston says.

The next cells to mature were the place cells, which are found in the hippocampus. These cells represent a specific place in the environment, and in addition provide contextual information – perhaps even memories – that might be associated with the place. Last to mature were grid cells, which provide the brain with a geometric coordinate system that enables the animal to figure out exactly where it is in space and how far it has travelled. By the time the rat pups were 30 days old, or on the threshold of rat adolescence, virtually all of the different navigational cell types had matured.

A surprising sequence

"There was no data about the sequence of development of head-direction cells, place cells and grid cells before we conducted this investigation," explains Langston. "But since the discovery of grid cells, it has been hypothesised that they are the basis of the navigation system, so it would be logical to believe that they appear first in development. Our results suggest instead that the head-direction cells are involved in helping to establish the other two systems. We scientists always tend to love results that question previous models," Langston adds.

The findings are a partial answer to the age-old question of whether or not you are born with the innate ability to find your way around. "The rats seem to be equipped with the basic foundations of a system that is ready to navigate as soon as the rat needs it. We can compare the system to a newly built library where the shelves are in place from the start, and the shelves are gradually filled with books and notes as you have interesting experiences," Langston says.

Many of the journalists who interviewed Langston after the article in Science took note of the fact that the results showed no difference in navigational systems between male and female rats. "We have not studied men and women, so we can't exclude the possibility that there are differences in people that are not found in rats. Perhaps the age-old question of whether men or women have a better sense of direction could be a case of how we choose to build our maps, rather than the materials we start with," suggests Langston.

Rats and humans

Rosamund Langston is now at the School of Medicine at the University of Dundee, where she is the director of a new lab. "We are trying to bridge the gap between memory tests in humans and animals by focusing on investigating the neural basis of episodic memory, which is severely impaired in patients with Alzheimer's disease. The Moser Group will be continuing the study of the development of navigation skills, while I will be looking at the same problem using different sorts of memory tests. The hope is that we can complement each other's research in the quest for a better understanding of the brain, in order to develop a cure for Alzheimer's disease and other diseases in the future," Langston says.

Langston's new research project exposes rats to memory tests that are similar to those that people might recognize from newspaper or magazine "spot-the-difference" puzzles. "You can measure how much the rats remember about their environment by measuring how much they notice when you change something," explains Langston. "If you present a rat with a known environment that contains new objects, it will immediately go and explore the changes. I have tested similar tasks on classes of students, and it often takes them quite a long time to spot the differences between two drawings. The rats are able to spot differences more or less automatically," Langston says.

Brain Science and Philosophy

The Kavli researchers' discovery in 2010 has cast new light on a question that philosophers have discussed since Aristotle's time: Is a newborn human being a *tabula rasa* – that is, a blank slate, an individual without any innate mental content?

"The German philosopher Immanuel Kant believed that the human ability to perceive things in time and space may be congenital or *a priori*. Although Kant does not formulate the theory so specifically, we can say that our results confirm Kant's basic idea. But we must naturally take into account that our rats were not studied immediately after they were born, but 15 days later," says Professor Edvard Moser.

Laura Colgin receives the International Gruber Award

Kavli Postdoctoral Fellow Laura Colgin received the Peter and Patricia Gruber International Research Award in Neuroscience in 2010. The Society for Neuroscience (SfN) honoured Colgin for her outstanding research and educational pursuits in an international setting.

Laura Colgin received the prize for her work on determining how nerve cells use gamma waves to route information through the hippocampus, which is important in learning and memory.

All brain cells produce electrical signals that convey information to other brain cells. When a large number of brain cells work together in a network that sends electrical signals at the same time, brain waves are the result. Brain researchers have long wondered why the brain has several types of gamma waves with different wavelengths and frequencies, but in November 2009, Laura Colgin and a group of scientists from KI/CBM published their sensational findings in an article in the journal Nature.

"The brain uses lower frequency gamma waves when it calls up memories of past experiences. But if the brain wants to address what is happening here and now, such as sensory input about where you are and what you are experiencing, it uses gamma waves with higher frequencies. The different frequencies make it possible for the brain to distinguish between different types of information, for example, between memories and the news, even if the brain is working with them simultaneously," explains Colgin, who was the first author of the Nature article.
In other words, Colgin's research showed that the brain works a bit like a radio station: Different types of signals are separated via different frequencies and wavelengths.

The reasons behind schizophrenia

One of the goals of the research in Trondheim has been to find a cure for Alzheimer's disease. Laura Colgin may instead have come closer to unravelling the reasons behind schizophrenia. "We do know that gamma waves are abnormal in schizophrenic patients. Their perceptions of the world around them are mixed up, like a radio stuck between stations. It would be very interesting to investigate the general role of gamma waves in diseases of the brain," she says.

Laura Colgin received her doctorate in the United States at the University of California at Irvine. "I'm very glad I got to come to Trondheim as a postdoc, because this is an excellent research institute with a great academic environment, along with very nice people," she says.

The Gruber International Award in neuroscience was also awarded to Jason Shepherd, PhD, of the Massachusetts Institute of Technology during Neuroscience 2010, SfN's annual meeting and the world's largest source of emerging

Laura Colgin received the Peter and Patricia Gruber International Research Award in Neuroscience in 2010.

news on brain science and health. The award recognizes two promising young scientists for their outstanding research in an international setting.

"We applaud the accomplishments of these young scientists and expect to see exciting contributions from them in the years to come," said Michael E. Goldberg, MD, president of SfN.

On the trail of the brain's cartographer

Researchers at the KI/CBM have previously shown that the entorhinal cortex in the rat brain contains specialized cells that form the grids in the rat's mental map of its surroundings. Now researchers also have found grid cells elsewhere in the brain. The next step is to investigate where the grids and maps come from.

"The brain in mammals uses grid cells, place cells, head-direction cells and border cells when the animal navigates in an environment. Until now, grid and border cells had only been found in the medial part of the entorhinal cortex, which functions as a hub in a wide-spread network for memory and navigation in the brain. But we discovered that grid cells were also abundant in other areas. We recorded many of them intermingled with head-direction and border cells in the areas called presubiculum and parasubiculum," explains PhD candidate Charlotte Boccara.

The presubiculum and parasubiculum are two small areas that are "upstream" of the medial entorhinal cortex, in the sense that they send signals there. These two areas are in fact responsible for some of the major inputs to the medial entorhinal cortex, explains Boccara, who was the lead author of an article in the August 2010 issue of Nature Neuroscience.

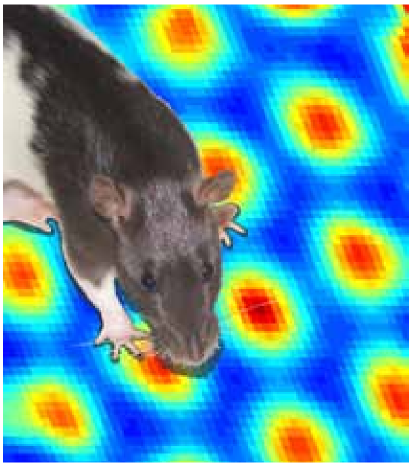
How the brain generates maps

After Boccara and her colleagues in the Moser Group at KI/CBM found grid cells in two new areas of the brain, they were able to formulate three hypotheses about how the grid pattern in the brain is actually generated.

"One possibility is that grid cells in the presubiculum and parasubiculum generate the grid pattern inherited by the medial entorhinal cortex. Another possibility is that it's actually the grids in the medial entorhinal cortex that are in the 'driver's seat' and generate the signal, while the third possibility is that the patterns in the three regions are all generated the same way. We have the most faith in the last option," explains Boccara, who has already begun to think of a research project to test the three alternatives.

"The presubiculum and the parasubiculum are not identical to the medial entorhinal cortex, but they share some properties and some connections. The finding should help further our understanding of how the brain generates the internal maps that help us remember where we have been and how to get to where we want to go," Boccara adds.

PhD candidate Charlotte Boccara, originally from Paris, was lead author of an article in the August 2010 issue of Nature Neuroscience. (Photo: KI/CBM)



A grid cell in the rat brain – and probably in all mammals – fires an electrical signal whenever the rat passes specific points in the environment. Many interoperable grid cells fire electrical signals at spatial points, which together form a coordinate system of the surroundings.

The brain's navigation system

Grid cells are an important part of the mammalian brain's built-in navigation system. Grid cells provide geometric coordinates for locations and help the brain generate an internal grid to help in navigation. The grid cells enable the brain to generate a series of maps of different scales and help with recognition of specific landmarks. The navigation system also consists of place cells, which code for specific locations, head-direction cells, which act like a compass, and border cells, which define the borders of an environment.

A cavalcade of award winners

Kavli Prize Week 2010 was celebrated in Oslo by King Harald's presentation of the Kavli awards to the year's eight laureates, and in Trondheim with lectures and talks by one Nobel laureate and four Kavli Prize winners who came to inspire and be inspired.

Nobel laureate Eric Kandel received a standing ovation when he held the Kavli lecture in Trondheim in 2008 with the title "We are what we remember". The interest in Kandel's presentation was just as great when he came back in 2010 but this time, the Nobel laureate and brain researcher shared the podium with his sociologist wife, Denise Kandel. She is known for having developed the so-called gateway theory, which says that the use of one drug dramatically increases the risk of moving to a new, more serious drug.

Denise and Eric Kandel began studying together after the latter received the Nobel Prize in Physiology or Medicine in 2000. Together they have shown that nicotine "primes" the brains of mice so that they are more susceptible to cocaine. Drugs create strong memories in brain cells and thus provide an impetus to repeat the drug abuse, in a mechanism that is similar to that which takes place in the brain during learning.

Trondheim's big day

Thursday 6 September 2010 was the big day for anyone in Trondheim who wanted to know more about research at the forefront of international science. In addition to Kandel, four of this year's Kavli Prize winners participated in seminars and other events at NTNU: Nadrian Seeman and Donald Eigler, winners of the nanoscience prize, and Thomas Südhof and Richard Scheller, winners of the neuroscience prize. Eigler essentially started nanotechnology as an engineering discipline in 1989 when he was able to move 35 xenon atoms in such a way that they spelled out the name of his employer, IBM. Seeman was the first to use DNA as building blocks in nanotechnology, in 1991.

It was especially gratifying for researchers at the KI/CBM to be visited by Kavli neuro laureates Richard Scheller and Thomas Südhof, whose major contributions have been to document how the synapses – the contact points between neurons – work. Südhof gave a popular science lecture in the morning and later had time to attend an experiment in the institute's laboratory, while Scheller spoke at an academic seminar for brain researchers. Südhof is a professor at the Stanford University School of Medicine in the US, and Scheller is now Executive Vice President for Research & Early Development at the biotechnology company Genentech. The two shared the Kavli prize in neuroscience with Professor James Rothman at Yale University.

This year's Kavli prizes in astrophysics went to Jerry Nelson of the University of California, Santa Cruz; Ray Wilson, formerly at Imperial College London and the European Southern Observatory; and Roger Angel of the University of Arizona, Tucson.

Second round of Kavli awards

This marks only the second time Kavli winners have been chosen since the biennial prize was launched in 2008. Funding for the awards comes from the California-based Kavli Foundation, established in 2000 by Fred Kavli, a Norwegian-born physicist, entrepreneur and philanthropist.

The Kavli Prize in neuroscience was awarded to Richard H. Scheller, Thomas C. Südhof and James Rothman. Fred Kavli to the right. (Photo: Terje Bendiksby, Scanpix).

Neuroscience can provide a cure for Fragile X syndrome

Fragile X syndrome is the most common inherited form of mental retardation and is caused by an abnormality on the X chromosome. "Neuroscience can develop a drug against the syndrome in two to five years," said an optimistic Professor Mark Bear during the Annual Kavli Lecture 2010.

Fragile X syndrome (FXS) is an inherited disease that can develop as mental retardation, behaviour problems, psychological difficulties and bodily changes. The disease got its name because the X chromosome in individuals with the disease is fragile and tends to crack when it is studied under a microscope. The disease occurs in approximately 1 in 4000 boys and 1 in 8000 girls, with the first symptoms seldom appearing before the age of five.

The leading American neuroscientist Mark Bear has shown that FXS is due to an imbalance in protein production in the brain, which results from an inability of the brain cells to check the synthesis of the protein. His research has led to an international race to develop new drugs to treat the syndrome.

The starting point for Bear's research is that proper brain function requires the sculpting of connections between neurons during early postnatal life. Synapses are formed and strengthened, or weakened and lost, under the influence of sensory experience. More than four decades of research on the visual cortex have now culminated in a deep understanding of the mechanisms responsible for whittling away inappropriate synaptic connections. Insights derived from this line of research have recently suggested the remarkable possibility of new treatments for FXS.

High hopes

Professor Bear described his groundbreaking research to an attentive audience during the Annual Kavli Lecture 2010 in the Student Society building in Trondheim.

"We know that mice with Fragile X syndrome get better after treatment with one of the new medications, and clinical testing on humans is already under way. I have great hopes, but there is still a long road ahead," said Bear.

"If FXS is attacked at an early stage with the new medications, I believe that brain function will have a chance to develop more normally. It is more unclear as to whether the drug will have as much of an effect on brain function in adult human brains that are already completely wired together," explained Bear.

Understanding in order to repair

The KI/CBM management team invited Professor Bear to hold this year's Kavli lecture because his results represent a triumph of basic research. By finding out how the brain works, researchers have been able to identify what is wrong when it does not work properly. And the understanding of what is wrong can make it possible to find out how malfunctions in the brain can be corrected. Mark Bear believes that drugs for FXS could also work for autism, among others, which is far more common and affects approximately one out of 150 people.

If we add up all the debilitating diseases affecting the brain and nervous system, such as stroke, cerebral palsy, epilepsy, multiple sclerosis, Parkinson's disease, head injuries and chronic pain conditions, along with psychiatric disorders such as depression, schizophrenia and addiction problems, the total represents about one-third to one-half of all morbidity in Norway. Brain research and neurosciences can therefore contribute to a major reduction in human suffering and social costs.

The 2010 Kavli Lecturer, Dr. Mark Bear, is a Howard Hughes Medical Institute Investigator and the Picower Professor of Neuroscience at the Picower Institute for Learning and Memory and the Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology.
(Photo: Hege Tunstad)

Making the brain more visible

Media coverage of the KI/CBM in 2010 demonstrates that the centre remains one of the most visible Norwegian research institutes in the fields of biology and medicine.

Professors May-Britt and Edvard Moser have been popular interview subjects for the Norwegian and foreign media since the research centre was first established in 2002, but in 2008 the centre changed its media strategy, in part because working with the media was beginning to be very time consuming for the researchers. The new strategy is to prioritize the largest and most important research news and media – and 2010 statistics show that the change has been very successful.

The total number of stories and postings on television and in newspapers has dropped somewhat, but according to Retriever, a media analysis service, the value of the coverage that the centre has received has increased greatly.

The result is that brain researchers in Trondheim have contributed even more to make the brain visible than they have done in previous years. Statistics show that there have been about 70 articles or posts about the KI / CBM in the Norwegian media, and about 40 reviews and quotations in European, American, Asian and African media.

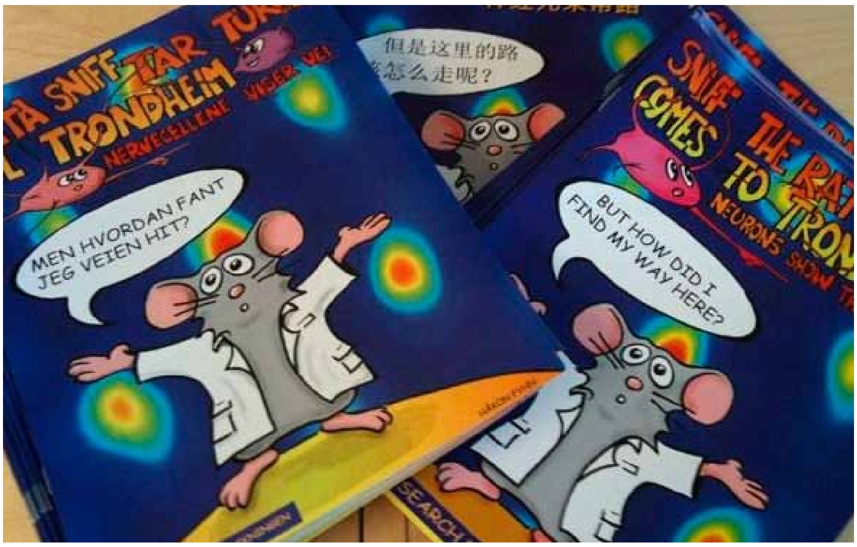
The biggest research news during the year came when Ros Langston and a group of researchers at the KI/CBM published a research article in the scholarly publication Science. The article showed that rats are born with at least a rudimentary sense of place (see pages 4 and 5) and was quoted in a number of Norwegian and many foreign media.

The New York Times interviewed Langston and even conducted its own test on travellers at the Union Square subway station, with results that seemed to confirm Langston's results. The test was conducted under the supervision of Professor James B. Ranck, Jr., who in 1990 discovered head-direction cells in adult rats.

Sniff the Rat ponders the complexities of the brain

KI/CBM also participated in the NTNU Museum of Natural History and Archaeology's exhibition on "Research and the Future", which was visited by more than 40 000 people over nine months. The exhibition highlighted the fact that it had been 250 years since the establishment of the Royal Norwegian Society of Sciences and Letters and 100 years since the establishment of the Norwegian Institute of Technology – the forerunner of NTNU in Trondheim.

A comic book and a computer game about Sniff the Rat were created for the exhibition, as a way to convey the pioneering discoveries made at the Kavli Institute in a simple and straightforward manner. Sniff the Rat wanders around Trondheim, while pondering the marvels of the brain and how its cells are linked together in networks, about how head-direction cells alert him when he turns his head, and how place cells are linked with memory cells. The comic was later translated into both English and Chinese, the latter after a call from NTNU's Faculty of Medicine.



It doesn't really help to remember all the places we've been if we can't put them in relation to each other, according to Sniff the Rat.

Who's who at KI/CBM

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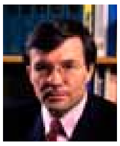

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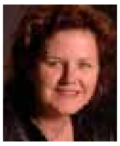

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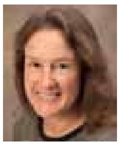

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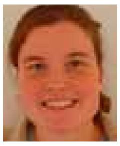
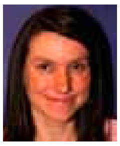

Cathrin Canto
Researcher
Witter group


Jonathan Whitlock
Researcher
Moser group

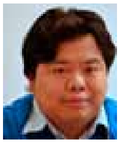

Laura Colgin
Researcher
Moser group


Karel Jezek
Researcher
Moser group


Noriko Kogonezawa
Researcher
Witter group

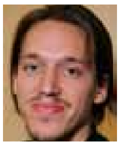

Trygve Solstad
Researcher
Moser group


Alexandre Daniel Surget
Postdoc
Tashiro group


Aree Widya Witoelar
Postdoc
Roudi group


Calvin Young
Postdoc
Tashiro group


Dori Dedrikamn
Postdoc
Moser group


Emilio Kropff
Postdoc
Moser group


Hideki Kondo
Postdoc
Witter group

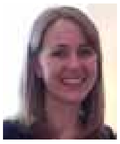

Hiroshi Ito
Postdoc
Moser group


Jay Jonathan Couey
Postdoc
Witter group


Jing Ye
Postdoc
Moser group


Kally O'Reilly
Postdoc
Witter group


Kei Igarashi
Postdoc
Moser group


Lisa Giocomo
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Masato Uemura
Postdoc
Tashiro group


Raveendran Rajeevkumar Nair
Postdoc
Tashiro group


Rosamund Langston
Postdoc
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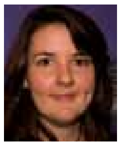
Takuma Kitanishi
Postdoc
Tashiro group


Tiffany Van Cauter
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ON SABBATICAL LEAVE


Marianne Fyhn
Researcher
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Torkel Hafting Fyhn
Researcher
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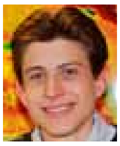
GRADUATE STUDENTS


Albert Tsao
PhD candidate
Moser group


Alessandro Luchetti
PhD candidate
Tashiro group


Charlotte Alme
PhD candidate
Moser group


Charlotte Boccara
PhD candidate
Moser group


Chenglin Miao
PhD candidate
Moser group


Espen Joakim Henriksen
PhD candidate
Moser group


Grethe Mari Olsen
PhD candidate
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Hanne Stensola
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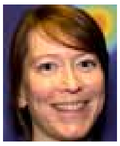
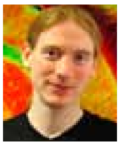

Ingvild Kruge
PhD candidate
Moser group

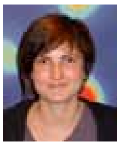

Li Lu
PhD candidate
Moser group


Mathias Mathiasen
PhD candidate
Witter group


Stefan Matthias Blankvoort
PhD candidate
Tashiro group


Tora Bonnevie
PhD candidate
Moser group


Tor Stensola
PhD candidate
Moser group


Tanja Wernle
PhD candidate
Moser group

MASTER'S STUDENTS


Fan Zheng
Master's student
Moser group


Nenitha Charlotte Dagslott
Master's student
Tashiro group


Øystein Rød Brekk
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Tashiro group


William Espen Windsor
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Ingrid Amellem
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Tashiro group


Abdala Mumuni Ussif
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Witter group


Asgeir Kobro-Flatmoen
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Witter group

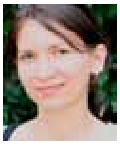

Sobia Islam
Master's student
Witter group


Christian Gjeraker
Master's student
Witter group


Lilliane Hansen
Master's student
Witter group

ADMINISTRATION


Hege Tunstad
Communication Officer
Support group

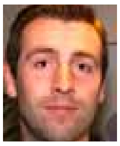

Iuliana Hussein
Head of office
Support group


Linda Veres
Executive Officer
Support group


Unni Iversen
Senior executive officer
Support group

TECHNICAL TEAM


Merethe Andresen
Animal care
Support group



Tommy Åsmul
Animal care
Support group

Alice Burøy
Molecular biology
Moser group

Ann Mari Amundsgård
Histology, hyperdrives
Moser group

Bruno Monterotti
Anatomy
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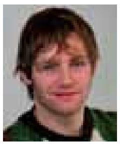
Ellen Husby
Anatomy
Witter group



Endre Kråkvik
Molecular biology, hyperdrives
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Haagen Waade
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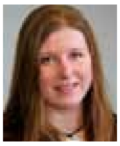

Ingvild Hammer
Infrastructure
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Kyrre Haugen
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Moser group

Ragnhild Giestad
Anatomy
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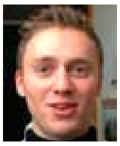
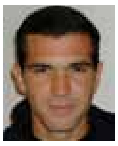


Raymond Skjerpeng
Programming
Moser group

Teruyo Tashiro
Neurogenesis
Tashiro group



Paulo Giao Bettencourt
Anatomy
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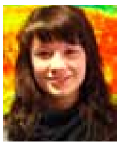
RESEARCH ASSISTANTS

Jørgen Sugar
Research assistant
Witter group



Ida Aasebø
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Witter group

Juan Wu
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Zhang group

Chika Yoshii
Research assistant
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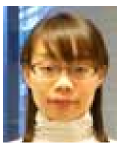

Naomi Kitanishi
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PROJECT STUDENTS

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Kristian Frøland
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Moser group

Tale Litlere Bjerknes
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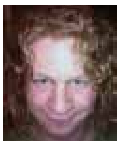
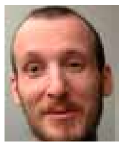


Øyvind Wilsgård Simonsen
Project student
Witter group

ASSOCIATED MEMBERS

Hanna Mustaparta
Professor NTNU, Biology



Robert Biegler
Associate Professor NTNU
(Psychology)

Annual Accounts 2010

Income	
Transferred from 2009	-1 401 416
Research Council of Norway: Centre of Excellence	10 000 000
Research Council of Norway: other	11 077 000
International (EU 7th Framework programme, ERC, Marie Curie, James McDonnell Foundation)	21 341 000
Other public/private (Kavli Foundation, Contact Committee)	905 000
Norwegian University of Science and Technology	
Support to Kavli Institute from host institution and ministry	10 607 000
Return of overhead	4 822 000
Incentive funds EU/ERC	2 125 000
Total income	60 877 000
Expenses	
Net personnel costs	25 872 000
Overhead	8 256 000
Scientific equipment	5 000 000
Operational expenses	13 462 000
Total expenses	52 590 000
Transferred to 2011	**6 885 584**

Amounts in NOK

Publications

Langston RF, Ainge J, Cowey JJ, Canto CB, Bjerknes TL, Witter MP, Moser EI, Moser M-B (2010). Development of the spatial representation system in the rat. Science, 328, 1576-1580.

Boccara CB, Sargolini F, Hult V, Solstad T, Witter MP, Moser EI and Moser M-B (2010). Grid cells in pre- and parasubiculum. Nature Neurosci., 13, 987-994.

Henriksen EJ, Colgin LL, Barnes CA, Witter MP, Moser M-B, and Moser EI (2010). Spatial representation along the proximodistal axis of CA1. Neuron, 68, 127-137.

Colgin LL, Leutgeb S, Jezek K, Leutgeb JK, Moser EI, Mc-Naughton BL and Moser M-B (2010). Attractor-map versus autoassociation based attractor dynamics in the hippocampal network. J. Neurophysiol., 104, 35-50.

Colgin LL, Moser EI (2010). Gamma oscillations in the hippocampus. Physiology, 25, 319-329.

Derdikman D, Moser EI (2010). A manifold of spatial maps in the brain. Trends Cogn. Sci., 14, 561-569.

Derdikman D. and Moser M.-B. (2010). A dual role for hippocampal replay. Neuron 65, 582-584.

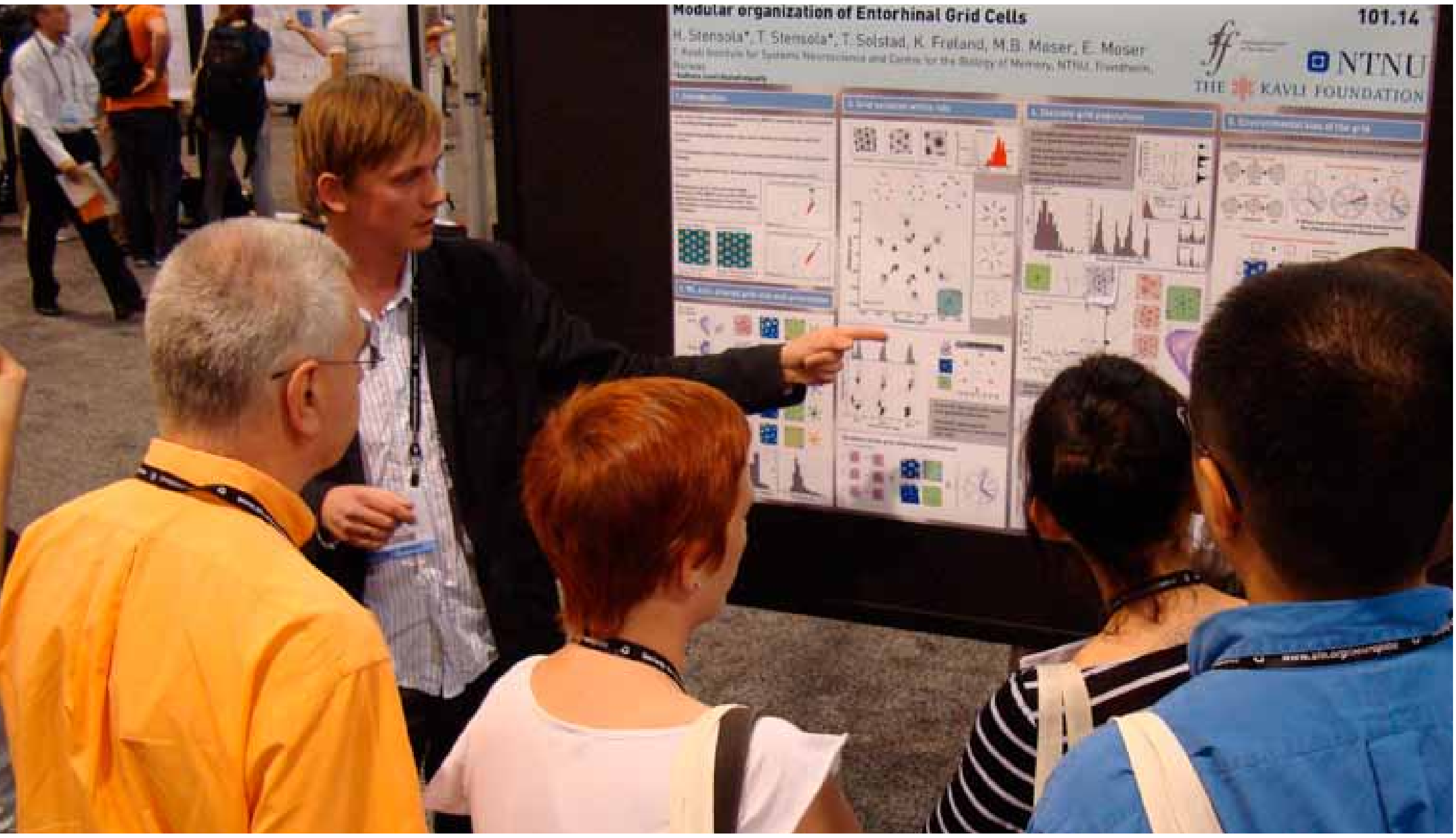
Alme CB, Buzzetti RA, Marrone DF, Leutgeb JK, Chawla MK, Schaner MJ, Bohanick JD, Khoboko T, Leutgeb S, Moser EI, Moser M-B, McNaughton BL and Barnes CA (2010). Hippocampal granule cells opt for early retirement. Hippocampus, 20, 1109-1123.

Witter MP (2010) Connectivity of the Hippocampus. In: Hippocampal microcircuits, (V.Cutsuridis et al eds), Springer series in Computational Neuroscience 5.. Springer pp. 5-26.

Hertz J., Roudi Y., Thorning A., Tyrcha J., Aurell E., Zeng H. (2010). Inferring network connectivity using kinetic Ising models. BMC Neuroscience 2010, 11 (Suppl 1):P51

Aurell E., Ollion C., Roudi Y. (2010). Dynamics and performance of Susceptibility Propagation on synthetic data. EPJ B. 77:587

Moser EI, Witter MP, Moser M-B (2010) Entorhinal cortex. In: Handbook of Brain Microcircuits. Shepherd GM, Grillner, S Eds. Oxford Univ Press, Oxford, UK pp175-192.



FOOTBALL IS ALSO BRAIN RESEARCH

The Norwegian media have become aware that brain research can be used to shed light on many interesting topics. Schrödinger's Cat, the science and technology television programme produced by NRK, the Norwegian National Broadcasting Corporation, did exactly that when reporters used research to explain why some footballers are especially skilled scorers. Football player Harald Brattbakk, who has 166 goals at the top level, explained that he felt as if he had a kind of instinct for situations where he could score. KI/CBM director Professor Edvard Moser offered the comment that his instinct may have something to do with memory.

"There is often talk of the ability to predict what will happen in the next few milliseconds, and that ability is quite dependent on having stored images of previously experienced goal situations in the brain. These can be retrieved in just a few milliseconds, and the brain can then tell you what you have to do to make the next move, partly based on past experience," explained Moser.

The Biology of Memory and Systems Neuroscience

Researchers at KI / CBM explore the brain's functioning by detecting and analysing the electrical signals in the brain. In 2009, KI / CBM also began an active expansion into genetics and molecular biology in order to increase its tool box for studies of neural network actions in the performing brain.

Since the centre's inception, KI / CBM researchers have used laboratory rats as study animals. The rats run around in boxes and corridors in search of food and have very thin electrodes inserted into their brains, primarily in the regions of the brain called the hippocampus and entorhinal cortex. This enables researchers to detect brain activity.

The hippocampus is an older part of the cerebral cortex and has a central role in the functioning of human and animal memory. The entorhinal cortex contains grid cells, border cells and direction cells that together give the brain the ability to make highly advanced maps.

The electrodes don't need to be inserted directly into the nerve cells, but instead are placed gently in the space outside of the cells. Each electrode can then record the electrical activity in many brain cells at once, but the electrodes are so sensitive that it is possible to distinguish between the different signals from each individual neuron.

A series of important findings

The KI/CBM has produced a series of sensational scientific findings. In its first year, researchers found that direct inputs from the entorhinal cortex to the hippocampus are responsible for spatial orientation. In 2004, they showed that the entorhinal cortex contains an accurate spatial map of the animal's environment. 2005 was marked by the discovery of grid cells in the entorhinal cortex, which form a map with coordinates comparable to those on a map you can buy in a bookshop. The following year researchers found cells that function like a compass and a speedometer.

The discovery of a completely new type of brain cell that registers borders and barriers caused scientific excitement worldwide when it was published in the American journal Science in 2008. In the same year, it was also discovered that the hippocampus has an inbuilt map with a number of different scales.

In 2009, researchers at the KI/CBM discovered both that the brain uses different wavelengths to separate experiences, and that the brain is able to create its own library of maps for specific purposes.

NTNU – Trondheim
Norwegian University of
Science and Technology

Annual Report for KI/CBM 2010

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The Norwegian University of Science and Technology (NTNU) is Norway's primary institution for educating the nation's future engineers and scientists. The university also has strong programmes in the social sciences, the arts and humanities, teacher education, medicine, architecture and fine art. NTNU's cross-disciplinary research delivers creative innovations that have far-reaching social and economic impact.

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