Facts about KI / CBM and KI / CNC

May-Britt and Edvard Moser established the Laboratory for Memory Studies at the Norwegian University of Science and Technology (NTNU) in Trondheim in 1996. In 2002, a ten-year-long grant from the Research Council of Norway enabled the laboratory to expand to become a Centre of Excellence (CoE). The new institution was named the Centre for the Biology of Memory (CBM).

In 2007, the Norwegian-American physicist, businessman, billionaire and philanthropist Fred Kavli selected the CBM as one of 15 prestigious Kavli Institutes worldwide. The centre accordingly changed its name to the Kavli Institute for Systems Neuroscience and the Centre for the Biology of Memory (KI/CBM).

The first CoE period expired in 2012, but the Research Council of Norway decided at the same time that the Trondheim research group should be awarded new funding. At the end of 2012-2013 the centre changed its name to the Kavli Institute for Systems Neuroscience and the Centre for Neuronal Computation (KI/CNC). KI /CNC is part of the Norwegian Brain Centre at NTNU in Trondheim, which is home to perhaps the largest infrastructure for systems neurophysiology in the world.

The centre’s basic approach has always been to understand the sense of location as a model for developing a deeper understanding of memory and the workings of the brain. The sense of location is closely linked to the hippocampus, where place cells were discovered in 1971. The researchers at KI/CNC have taken the plunge into adjacent and interacting brain structures, especially the entorhinal cortex.
Ten memorable years

“We are even more impressed and intrigued today by the sophisticated computations of the brain than we were ten years ago. And we are both proud and amazed at all the new knowledge we’ve accumulated over the past ten years,” says Professor Edvard Moser.

The Research Council of Norway decided on 12 June 2002 that Edvard and May-Britt Moser’s then-laboratory for memory studies in Trondheim should be expanded to be a Centre of Excellence (CoE), with a decade’s worth of generous funding. Just a week after the award, the researchers published an article in the journal Science, reporting they had found that direct connections from the cortex were enough to form a spatial map in the hippocampus. The finding hinted that the mammalian sense of location was not confined to the hippocampus.

It’s not every day that Norwegian researchers publish in international journals such as Nature and Science, but for Edward and May-Britt Moser, this was only the beginning. In the years that followed, the two published 16 original research articles in these journals.

The discovery of grid cells and mechanisms behind the sense of location

Perhaps the duo’s most widely recognized finding was in 2005 with the discovery of so-called grid cells in the entorhinal cortex, a brain structure that connects the hippocampus with the rest of the cortex. Grid cells react and send electrical signals at spatial points that combined form a triangular, Chinese-checkers-like grid.

In 2006 came the news that the entorhinal cortex also contains neurons that encode how fast a rat is moving and in which direction. The brain, in other words, has a GPS, a speedometer and compass, the researchers reported.

In 2007, the Moser group showed that grid cells form universal maps that are applicable to any environment visited by the rat. The internal metrics of the map are preserved from one environment to the other. Two cells will also fire in the same place in one room will fire at the same places in another room. This differs radically from the maps of place cells in the hippocampus, where different combinations of active cells are recruited for every environment. The grid map is like a ruler, which should stay the same no matter the location, whereas the place cells are part of the memory system, where every memory should be as distinct as possible.

In 2008, the Mosers and their students created another stir with the discovery of so-called border cells in the entorhinal cortex, which “fire” electrical signals in laboratory rats when the animals approach a wall, a fence or a drop.

From single cells to complex networks

Brain waves are generated when billions of neurons communicate with each other by means of tiny electrical impulses. In 2009, KU/CBM researchers discovered that the brain uses gamma brain waves to filter incoming messages to the place map in the hippocampus. When place cells in the CA1 area oscillate at low gamma frequencies, they are tuned to inputs from the CA3 area. When they oscillate at higher frequencies, they are primarily sensitive to inputs from the grid cell area in the entorhinal cortex. Thus the hippocampal system is similar to a radio station that broadcasts information about location on one frequency and archive material from memory on a different frequency.

In 2010 we learned that rats come into the world with a rudimentary sense of location. In 2011 we learned that various memories are stored as indivisible packets or “quanta” in the brain, without being mixed with each other. In 2011, researchers at KU/CBM found a protein that controls a kind of zoom function in the rat brain navigation system, and in 2012 came the sensational news that researchers in Trondheim had proved that the sense of direction in the mammalian brain is organized into independent modules (see separate article). The discovery of modules provides strong evidence of how the most elevated parts of the cortex are organized and was thus a great end to the first CoE decade. And now the work will continue for at least another ten years.

Grid cells were the biggest find

“If I have to rank the findings, the discovery of grid cells would be the most important up to now. It actually defined a whole new research area. But it is also important to recognize that grid cells coexist with several other cell types that are important for the sense of direction, such as border cells and direction cells. Our research has shown how these cell types are organized in complex networks. The discovery of grid cell modules illustrates a new way to organize the cortex, and will probably eventually prove to be as important as the discovery of grid cells,” says Edvard Moser.

“There is more and more evidence that neural wiring is ‘hard-wired’ from birth, and that the brain uses hardwired space networks as a framework to save memory. We see that the sense of location and memory are closely linked. If you remember an important experience, you also remember the location,” he adds.

Edward and May-Britt Moser have come much farther than they could have dreamed of ten years ago.

There has been rapid development on two fronts. Firstly, we have been able to record the activity of many more neurons simultaneously, from anywhere in the brain simultaneously, and we have the technology to control the activity of specific groups of cells while measuring the activity of the other groups. Secondly, we have been involved in a major conceptual development, in the...
The brain is much better than the computer

In the research group’s annual report from 2002, Edvard Moser drew a number of comparisons between the brain and the computer. Ten years later, he emphasizes how much better the brain is than the computer. Computers must still pretty much do things sequentially, or in one step after another, and even the best have only a small number of parallel processors that operate independently.

“In comparison, the brain runs hundreds of thousands of processes interactively and in parallel, and therefore is very good at drawing conclusions on the basis of unclear or ambiguous information. That is why the European Commission provided the KI/CBM with funding for a research initiative that aims to use the knowledge of how the brain functions to develop better computers. It’s going to be very exciting,” Edvard Moser says.

Edvard and May-Britt Moser emphasize that they got a good start in their career during their studies with the legendary Professor Per Andersen at the University of Oslo. “It has also been very important that we have had a group of seven visiting professors who come here not just to give lectures, but also to do research with us. Our good friends and partners deserve a great deal of the credit for our efforts having gone as well as they have,” says Edvard Moser.

Of particular importance is the collaboration with Menno Witter, which started in 2000. Two years before CBM was established. Witter became the third professor of the Kavli Institute in 2007. His move to Trondheim intensified the collaboration and many of the key findings of the Centre are true products of this effort.

From research group to institute

When CBM was established in 2002, the centre consisted of May-Britt and Edvard Moser and their research group of approximately 10 people, including PhD students and technical staff. During the next 10 years, the number of coworkers increased and an increasing percentage of the staff were postdoctoral fellows who came from all over the world to learn about grid cells and neural circuits in the hippocampus and entorhinal cortex.

With its recognition as a Kavli Institute, the Centre was able to recruit Menno Witter from Amsterdam in 2007 and Yasser Roudi from Stockholm in 2010. Most recently, Eliff Kana was headhunted from the University of Oregon in 2012. The Centre is no longer a single research group but an institute composed of 5 groups and more than 100 scientists who work together towards a common goal of understanding neural computation in the cortex.

From CBM to KI/CBM

The Norwegian Brain Centre is already one of the world’s largest brain research laboratories of its kind. As of early 2013, the centre has approximately 90 staff members (600+ full-time equivalent). NTNU’s rector, Torbjørn Døgner, said at the opening that he hopes the centre will expand to closer to 150 employees over the next two to three years. The 4000 m² facility will continue the research conducted by the KI/CBM. The centre will also host select PhD candidates and researchers from Norway and abroad who need training in the latest technology focused on the brain.

“With the opening of the Norwegian Brain Centre, NTNU will take a major step closer to realizing the Norwegian Brain Initiative (NORBRAIN), which received NOK 80 million in a grant from the Research Council of Norway in October 2011. NORBRRAIN is structured around two Centres of Excellence – the KI/CBM and the Centre for Molecular Biology and Neuroscience at the University of Oslo – as well as one Centre for Research-based Innovation – the Medical Imaging Laboratory (MI Lab) at NTNU. The aim is to build one of the best neuroscience infrastructures in the world.

Prime Minister Stoltenberg was still smiling when he left Trondheim, carrying an extra brain cell – or more precisely, a model of a brain cell from a rat. The model was given to him by Professor May-Britt Moser as a token of appreciation of the government’s support for brain research.
First insights into the organization of the higher cortex

Brain researchers know a great deal about how neurons are organized in the lower parts of the cortical hierarchy, in the sensory and motor systems. In 2012, scientists got a first glimpse of how the higher cortical regions are organized, when researchers at the KI/CBM showed that the sense of location in the mammalian brain consists of independent modules.

There are several different ways to describe the 2012 research findings of Hanne and Tor Stensola and their counterparts in the Møller group at the KI/CBM. The first is as pure research news, that the sense of location in the mammalian brain can be seen as consisting of four independent modules. The second is that Norwegian research results were presented in a seven-page spread in Nature, the world’s most respected scientific journal. The third way to describe the news is that for the first time, scientists have gained an insight into how the higher parts of the cortex are organized.

This third description is the main reason that the discovery has been described as the most important by KI/CBM researchers since 2005, when Edvard and May-Britt Moser along with former students discovered grid cells in the entorhinal cortex (see page 2).

Scientists know that in the visual cortex and other lower parts of the cortex, neurons working with similar tasks are organized into columns and are located near each other. This applies, for example, to neurons that respond to particular aspects of vision, such as orientation or left or right eye input. But our knowledge of how neurons are organized in the higher parts of the cortex is minimal – the equivalent of a blank spot on a map.

A technological breakthrough

The background to the new breakthrough is that after KI/CBM researchers discovered grid cells in 2005, they immediately began to wonder how the brain stores all of its map-related information.

Does the brain store the map in one large patch that is continuous? Or is it divided into smaller sections? Does the brain store all of its map-related information or does it break it up into subzones? Or does it have a network of grids with a different scale each time they get a bit closer to the sensory area? These are the questions that motivated scientists to look for answers.

The experiments also showed that the grid cells in the entorhinal cortex, which is part of the brain's sense of location, are organized into independent groups or modules. The modules are independent because changes in the environment may lead to changes in one module without affecting the others.

Sense of location as mother to memory

Hanne and Tor Stensola also noticed that the navigation system in the rat brain has huge overcapacity. The rat would have managed with approximately 20 grid cells in each module, but instead has at least 1000 times that number. The result is an enormous number of possibilities for combinations, when thousands of cells in four to ten modules overlap the same area. This excess capacity presumably reflects the fact that it is extremely important to navigate properly, for the rat and for that matter for human beings. “The sense of location is the mother to memory. The excess capacity means that the brain’s navigation systems could continue to work even if the brain is weakened by ageing or injuries,” the researchers said.

The brain zooms in discrete steps

When Hanne and Tor Stensola started their project, researchers knew that the grid cells in the top of the entorhinal cortex draw a map with a small grid size, and that the grid size increases deeper in the brain. But they did not know whether the grid size increased gradually, or stepwise.

To answer this question, laboratory rats ran around in special boxes in the lab to look for treats, while the researchers recorded the electrical activity of grid cells at several levels in the entorhinal cortex. “We then saw that electrical signals from the upper grid cells ‘draw’ a triangular grid of the laboratory boxes, with roughly 30-40 centimetres between grid line intersections. Further down in the brain, we found, as expected, grid cells that draw a grid with larger triangles. We also observed that there is no overlap in the different mesh sizes that the brain draws,” says Tor Stensola.

In other words: A camera allows you to zoom continuously from the closest focusing distance to infinity, but the researchers found that the brain instead seems to “zoom” in a stepwise fashion.

“Grid cells draw a discontinuous grid. We could also conclude that the scale is on average 42 per cent larger each time the brain ‘zooms out,’” says Hanne Stensola.

The new research shows that a modular organization is found in the highest parts of the cortex, far away from areas devoted to senses or motor outputs. It is not possible to locate the different modules with a microscope, because the cells that work together are intermingled with other modules in the same area.

Research at a new level

Ever since Santiago Ramón y Cajal proved that the brain consists of separate units – neurons – instead of fused cells in a network, brain scientists have spent a great deal of time studying different cell structures and functions. As a result, we now know a great deal about these areas. But what remains to be understood is how neurons together create complex mental functions. The door began to open on this when Hanne and Tor Stensola’s article appeared in Nature.

“We have begun to describe how the different parts of the mapping system and sense of direction in the rat brain work together into a unified system. The new discovery is also a strong indication that rats – and other mammals – are born with a predisposition to use the sense of location as a basis for memory. The organization of the grid map is not primarily the result of experience and interaction with the environment,” says Tor Stensola.
**Actions speak louder than space**

Researchers at the KI/CBM have spent several years studying rat brain neurons that encode what the animals are doing. In 2012, Jonathan Whitlock and colleagues also found neurons that encode what the animal is planning to do. But the biggest surprise was to find parietal cells that were determined by the rat’s actions instead of its location.

When Jonathan Whitlock and four colleagues from the Moser group at the KI/CBM published an extensive paper in Neuron in February 2012, it was the result of four years of hard work training rats and studying neurons in two small but important regions of the rat brain. The posterior parietal cortex (PPC) lies behind the primary somatosensory cortex and plays an important role in producing planned movements. The entorhinal cortex is located in the medial temporal lobe and functions as a hub in a widespread network for memory and temporal lobe and functions as a hub in forming plans and is known to be important in the planning of movements. The open field was in fact the same box that was used in the hairpin maze experiment - the only difference was the insertion of walls. The next stage was even smarter:

“We took the walls out of the box and trained three rats to run in the open field as if the walls were still there. This took many weeks, of course, but the result was very interesting. We found that structuring the animals’ behaviour into north-south hairpin-like sequences was sufficient to cause the cells to change their firing properties. This caused almost the same magnitude of flip as we saw between the open field and the real hairpin maze,” Whitlock explains.

Jonathan Whitlock and his colleagues thus became the first researchers who were able to investigate whether space or behaviour is more important in driving parietal cells.

“It became very clear that the structure of the animals’ behaviour is the primary thing that determines when the cell is going to fire. It was very unexpected to discover that actions speak louder than space in the posterior parietal cortex. This also means that there is a functional split between the parietal and entorhinal cortices in the rat,” Whitlock says.

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Jonathan Whitlock (left) was the lead author of the article in Neuron February 23, 2012, shown here with Nenitha Dagzlott, the second author. The other authors were Gent Flügel, May-Britt Moser and Edvard Moser. (Photo: Marcin Kowalczyk, NTNU).

**Behaviour beats space**

Does this mean that the neurons in the PPC respond to actions and not to locations? To find out more, the researchers decided to use two different mazes in the exact same location in the lab. The open field was in fact the same box that was used in the hairpin maze experiment - the only difference was the insertion of walls. The next stage was even smarter:

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Jonathan Whitlock’s results make an important contribution to understanding whether PPC and MEC signals have been seen in rats,” Whitlock says.

**Decoding the future**

Jonathan Whitlock not only observed that the parietal cells were mostly governed by actions. He also discovered that the firing properties of the parietal cells started to become very clear before the animal made their movements. In other words, the researchers were actually able not only to see what the animal was doing, but what it was planning to do.

“If the rats were making simple decisions about where to go in the open field, we could see that the forward looking ‘spotlight’ in the neurons appeared up to about a half a second into the future. But we hypothesize that if the animal was given a task where it had to choose between two specific goal locations, we might be able to see the spotlight extend several seconds in advance,” he says.

Is Whitlock actually reading the animals’ minds? “The answer is no. But we showed in principle that it is possible to do that. Other researchers have made similar observations in primates, but this is the first time that planning-related signals have been seen in rats,” Whitlock says.

The best place in the world

Jonathan Whitlock’s results make an interesting overture to the research that will be conducted at the Centre for Neuronal Computation during the next ten years.
Norway gets a national Research School in Neuroscience

Four universities are joining forces to establish the Norwegian Research School in Neuroscience in 2013. The school will be coordinated from the Norwegian Brain Centre and the Kavli Institute in Trondheim, with an enthusiastic Professor Menno Witter as director and chairman of the board.

The Research Council of Norway has decided to fund ten new national research schools, and the Norwegian Research School in Neuroscience (NRSN) is going to be one of them. Professor Menno Witter is looking forward to having a school to run again, because he has very good memories from when he was the director of the Graduate School in Amsterdam for eight years. That school was – and is – both great fun and a great success, and Witter’s ambition is to make the NRSN a similar success for both Norwegian neuroscience and the four participating institutions.

“The Norwegian Research School in Neuroscience, which will start its activities from 1 March 2013, will provide an important training opportunity for the next generation of Norwegian-trained neuroscientists, by combining the specific expertise of the participating institutions. I expect that it will also pave the way for more extensive collaborative neuroscience in Norway,” says Witter.

Molecular biology shines new light on the brain

In 2012, Clifford Kentros became the fourth professor at the Kavli Institute and the leader of a new research group. Kentros adds new strength to the institute with a set of molecular and genetic tools that are specially designed to unravel the wiring and functioning in the brain.

Professor Clifford Kentros describes himself as a recovering molecular biologist. He has been the leader of a research group in molecular genetics at the University of Oregon for several years, and has both admired and collaborated with Edvard and May-Britt Moser and Menno Witter. The collaboration made it increasingly clearer that Kentros could make important contributions to the Kavli Institute, so the solution became obvious. Professor Kentros is now a bi-continental scientist with one research group in Oregon and the other in Trondheim.

Kentros, like all the other Kavli Institute scientists, is intrigued by the brain structures that are necessary for memory. While Edvard and May-Britt Moser are specialists in recording and analysing electrical signals from neurons in and around the hippocampus, Kentros’s forte is transgenic mice that have been developed in Oregon. A transgenic mouse is a mouse where researchers have introduced a gene from another organism.

The brain is an electrical circuit

The main objective of the research school is to coordinate and complement existing educational activities with the partner and affiliated institutes, thereby providing additional training to PhD candidates in genetic, molecular, and cellular neuroscience, systems neuroscience, cognitive neuroscience and neuropsychology, neurophilosophy, developmental neuroscience, computational neuroscience, and neuroinformatics.

The NRSN is a virtual school with no teachers or courses of its own. The school instead will use existing courses at the different institutions and make those available to students from the other universities. The aim of NRSN is to organize and secure a broad, diverse, and nationally coordinated neuroscience training programme for PhD students in Norway.

The research school will be based on the partners’ existing PhD programmes. It will also exploit NOBRRAIN, the recently established national neuroscience infrastructure programme. All courses will be available to all neuroscience PhD students in Norway. The NRSN also has an extensive international network.

In older days, when people would sometimes do their own car repairs, it was common to find a drawing of the car’s electrical wiring right in the car’s manual. Professor Kentros is drawing a similar wiring diagram, but of the part of the brain that is involved in memory. In addition, he is trying to figure out the function of the different parts of the electric circuit.

“Molecular biology shines new light on the brain. The brain can be compared to an incredibly fancy and complicated foreign car. It is difficult to study the wiring diagram, but we have developed some very powerful tools,” Kentros says.

Checking the currents

Much as you might send an electric current through a wire in a car to see what it is connected to, Kentros is sending electrical signals between neurons to trace their pathways in the brain. This is where the transgenic mice come in.

“In one of the mice we made, we started with the genetic sequence that makes a neuron into a grid cell. We then introduced another gene from a cyanobacteria, which makes grid cells sensitive to light. We are able to use genetic techniques to engineer mice with grid cells that are turned off when light shines on them, as well as mice where the grid cells become more active, and so on,” Kentros says. “This corresponds to putting switches or meters on the grid cells, and they allow us to trace the electrical signals between neurons. I’m very much looking forward to using and developing these techniques further in collaboration with the excellent researchers in Trondheim.”
Brain researchers in Trondheim received a continuous stream of good news in 2012. The best news came from the government and the Research Council of Norway. Prime Minister Jens Stoltenberg’s visit in February received broad coverage in the Norwegian media. The Prime Minister met Edvard and May-Britt Moser and expressed congratulations to Professor May-Britt Moser, who was elected to a Chair of Excellence and to Edvard and May-Britt Moser. Past recipients have included four subsequent winners of the Nobel Prize for Physiology or Medicine. Edvard Moser was elected to EMBO in 2011.

Awards for excellent science

In December, the University of North Carolina at Chapel Hill awarded the 13th Perl UNC Neuroscience Prize jointly to Edvard and May-Britt Moser. Past recipients have included four subsequent winners of the Nobel Prize for Physiology or Medicine.

Kavli researcher Lisa Giocomo received a highly competitive “Starting Grant” from the European Research Council. She also received the Peter and Patricia Gruber International Research Award in Neuroscience from the Society for Neuroscience (SfN). Giocomo came to KICBM as a postdoc in 2008, and started on 1 Jan 2013 at Stanford University as an assistant professor in neurobiology.

Media coverage

Norwegian and foreign media are still interested in research at KICBM. The database of the media monitoring agency Retriever lists approximately 200 articles that were published about the research group in the Norwegian media in 2012, along with a number of television and radio broadcast reports.

The most widely publicized research result was the news that the sense of location in mammals consists of four independent modules (see separate interview with Hannie and Tor Stensola). Prime Minister Jens Stoltenberg’s visit in February and the news of the Research Council’s Centres of Excellence grant to KICBM was in the 1980s. The SAB also pointed out that the Centre’s full-time members have published more than 120 scientific papers, 18 of which were published by the most important international science journals (Science, Cell and Nature). They discovered “grid cells”, a new functional cell type, as well as head-direction cells and border cells intermingled with grid cells in the entorhinal cortex.

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Beginning with a small group of 3-4 graduate students and fellows, it has grown into a large, internationally renowned research centre involving 42 graduate students and fellows, 3 additional full-time faculty, and 7 visiting faculty from Europe and the United States who spend significant time working at the Centre,” says the report.

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We regard the Moser laboratory in the top 0.1% of this vibrant and diverse group. The Centre in Trondheim has become a magnet for systems and computational neuroscience that attracts the best young people in the world,” the report says. The top 0.1% of neuroscientists corresponds to a distinguished group of only 40. If the average size of neuroscience groups is 4, that puts the centre among the top 10 in the world.

The members of the Scientific Advisory Board in 2012 were Professor Larry Squire from the University of California, San Diego (Chairman), Professor Terrence Sejnowski from the Howard Hughes Medical Institute in Chevy Chase, Maryland, and the Salk Institute for Biological Studies in La Jolla, California; and Professor Erin Schuman from the Max Planck Institute for Brain Research in Frankfurt am Main.

“Among the top 0.1% of neuroscience centres”

The KICBM has had an active Scientific Advisory Board (SAB) composed of renowned international researchers since its beginning in 2002. The board has supplied the Centre with constructive criticism and lots of good advice over the years and has provided important contributions to the centre’s scientific progress.

The closing symposium of the KICBM, with the attendance of the SAB and the Centre’s visiting professors, was held in June 2012 on the picturesque island of Runde, on the western coast of Norway, just a few kilometers from where both May-Britt and Edvard Moser were born. The four group leaders at the KICBM – Edvard and May-Britt Moser, Meenakshi Witter and Yasser Roudi – gave talks about their results. The SAB wrote a report with very positive comments after the meeting.

Eighteen papers in Nature, Science and Cell

According to the SAB, it is difficult to overstate what the Centre has achieved.

When the Norwegian Ministry of Finance in September submitted its budget proposal for 2013, the document contained two key phrases:

“The Kavli Institute for Systems Neuroscience at the Norwegian University of Science and Technology in Trondheim is one of the premier research institutions in Norway. The Government proposes that NOK 12.5 million be earmarked for the centre in the state budget for 2013.”

And so it was: the Kavli Institute now has a separate line item in the state budget, in the form of a basic grant that will be used to finance infrastructure and the centre’s technical staff. The grant ensures stability for the centre’s operations and thus, better conditions for researchers to do excellent research in the future.

In November, the centre got even bigger news when the Research Council of Norway announced the award of a grant totaling NOK 175 million over ten years. (see separate article). Faculty of Medicine Dean Stig Slørdahl was on a business trip in the US when, in the middle of the night Norwegian time, he discovered that the award had been published on the Research Council’s website. He sent a text message with congratulations to Professor May-Britt Moser, who was happy to be awakened with that kind of news.

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Media coverage

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A passion to understand the brain

There were shouts of joy all around Professor May-Britt Moser when the news came on 12 November 2012: The Research Council of Norway had awarded the Centre for Neuronal Computation NOK 175 million (US $ 31 million) over the next ten years.

Then it was back to work – with a group of researchers who have stars in their eyes, driven by a passion to plumb the secret workings of the brain. The competition was fierce in early 2012 when the Norwegian Research Council invited research groups to submit applications for a new round of funding to establish Centres of Excellence (CoE). A total of 139 different research groups applied for funding, from which the Research Council first selected 27 finalists. Only 13 were awarded support in the end, with the Centre for Neuronal Computation (CNC) – led by Professor May-Britt Moser – one of the fortunate few.

“I am overjoyed and grateful for all the support the centre and its research has received from NTNU, the Norwegian Research Council, colleagues and collaborating labs,” Moser said.

The whole of NTNU also celebrated that day, because the Research Council awarded CoE funding to all four of the NTNU centres that had applied.

A clear vision

Professor May-Britt Moser has a clear view of what the Trondheim brain scientists will tackle in the next ten years.

“The vision is that we will uncover the basic mechanisms of complex brain functions but also genetic approaches to activating and inactivating specific cell populations,” says Moser.

“As and the trend is continuing” May-Britt Moser says. “It gives us hope that we will be able to deliver more exciting research results in the near future.”

Researchers have gradually accumulated a great deal of knowledge about how individual brain cells work and how they communicate. New researchers are focused more on understanding the neural networks in the brain better.

“Which brain cells ‘talk’ to each other? We are eager to find answers to this and similar questions, and now we have techniques that can help us,” says Moser.

Creating neurons with little ‘eyes’

CNC researchers are pioneering the fusion of optogenetics with neural ensemble physiology. Scientists can make brain cells sensitive to light in two ways, either by breeding mice with a genetic modification that means the mice are born with a light-sensitive receptor – rather like a small eye – in some brain cells, or by injecting a harmless virus that will infect cells that scientists want to activate during an experiment. The target neurons become active when researchers shine lights on them. The researchers can also use a virus that can be passed from one cell to the next, but that never spreads beyond the first new cell.

“Creating neurons with little ‘eyes’ is also important is that the centre be a showcase for the ethical treatment of animals – and for our human researchers, too. We hope that our scientists will have stars in their eyes, because we have put everything in place for them as best we can. We’re lucky that we can choose from among top-ranked students and researchers, because many of the best neuroscience research centres in the world like to send their best people to Trondheim. My job as manager is to make sure that the stars continue to twinkle in all of their eyes,” says Moser.

The 2022 annual report

“Where do you hope the centre is in ten years?”

“When we discovered both grid cells and border cells and had direction cells, and how the brain is able to tell the difference between this year’s and last year’s Christmas celebrations, and all the rest. Today we can use many more electrodes when we need to, “ says Moser.

“We have always carefully thought through new projects before they started, and we still do. But the long-term and good funding that we have now makes it possible to invest in riskier projects. We will be moving more in the direction of a high risk / high gain strategy. I will be very excited to share what we have found out when we write the 2022 annual report!” May-Brett Moser says.
Many leading international brain researchers visited Trondheim in 2012, both during the annual Kavli week and for other reasons. The most well-attended arrangement was Professor Richard Morris’s lecture on “The making, keeping and losing of memory.”

Kavli Public Lecture by Richard Morris
Professor Morris held his lecture during the Kavli Week in September, which added to a string of scientific pearls in Trondheim during the year. Two researchers held their Kavli prize lectures in Trondheim: The two neuroscience prize winners Professor Cornelia Isabelle Bargmann from Rockefeller University in New York and Winfried Denk from the Max Planck Institute for Medical Research in Heidelberg.

“We loved having the opportunity to meet and talk with these masters of the mind, and hope our guests feel the same way. Naturally we need to express our gratitude to Fred Kavli and the Kavli Foundation, as well as to the laureates. We are a happy and growing scientific family, and these Kavli events make the ties stronger every time,” said Professor May-Britt Moser.

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Kavli Distinguished Lecturers
In March, Nobel laureate Linda Buck from the Howard Hughes Medical Institute and the Fred Hutchinson Cancer Research Center in Seattle gave a lecture on “Deconstructing smell.” In June, Professor Oscar Marin and Assistant Professor Beatriz Rico from the Institute of Neuroscience in Alicante presented “Assembly of cortical circuits.”

Professor Giacomo Rizzolatti from the University of Parma, the discoverer of the mirror neurons, held a Distinguished Kavli Lecture in June on “How the actions of others are understood.” Professor Charles F. Stevens at the Salk Institute in La Jolla held a lecture in September on “Maps and anti-maps in the brain.”

In November, Dr. Philip Campbell, Editor-in-Chief of Nature and Editor-in-Chief of Nature-branded publications, held a lecture on “Publishing in Nature – and what happens afterwards.” The timing was not just by chance: a week later, the prestigious scientific publication devoted seven pages to the Trondheim researchers’ latest findings.

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Annual accounts 2012

Income
Norwegian Research Council: Centre of Excellence 10 000 000
Norwegian Research Council: other 28 139 000
International (European Commission, James McDonnell Foundation, Louis Jeantet Foundation) 12 296 000
Other Public/Private (Kavli foundation, Norwegian Health authorities) 3 143 000
Norwegian University of Science and Technology 35 508 000
Total income 89 086 000

Expenses
Net personnel costs 38 671 000
Indirect costs 23 564 000
Equipment 9 880 000
Operational expenses 16 971 000
Total expenses 89 086 000

Amounts in NOK
Publications

May-Britt and Edvard Moser

Publications


Abstracts


Menno Witter

Publications


Abstracts

Lu L, Leutgeb JK, Henriksen EJ, Tsao A, Leutgeb S, Barnes CA, Witter MP, Moser EI, Moser M-B. Sfn Abstr. 702.07 The lateral entorhinal cortex and rate coding in the hippocampus.


Ito HT, Witter MP, Moser EI, Moser M-B. Sfn Abstr.702.04. Representation of behavioural context in the nucleus reuniens for CA1 place cells.


Heggland I, Koganazawa N, & Witter MP. Sfn Abstr. 1758. Functional Networks In The Hippocampal Formation And Entorhinal Cortex Of A Transgenic Rat Model Of Alzheimer’s Disease.

Dahi A, O'Reilly KC. Witter MP. FENS Abstr. 3262. Subicular-To-Parahippocampal Projections In The Rat Are Present And Adult -Like Before Eye-Opening.


Yasser Roudi

Publications

Jason Sakellariou, Yasser Roudi, Marc Mezard, John Hertz

Effect of coupling asymmetry on mean-field solutions of direct and inverse Sherrington-Kirkpatrick model. Phil. Mag. 92, 272-279, 2012

Abstracts


T. Bonnevie, M. Fynh, B. Dunn, T. Halting, D. Derdikman, Y. Roudi, E.I. Moser, M.B. Moser. Entorhinal grid cells require excitatory drive from the hippocampus.

Lisa Giocomo

Publications


Witter MP. FENS Abstr. 3435. From Two-Dimensional Laminar Inputs To Three-Dimensional Interlaminar Integrated Networks.
Ten years with Norwegian Centres of Excellence

In November 2012, the Research Council of Norway awarded NOK 2 billion over 10 years to 13 research groups to establish Norwegian Centres of Excellence (NCoE) starting in 2013. NTNU was awarded four of the new centres.

The Centre for the Biology of Memory (CBM), led by Edvard and May-Britt Moser, was one of the initial 13 centres established in 2002, when the Research Council launched its first NCoE scheme. In 2007, eight new centres were established.

The Norwegian Minister of Education and Research, Kristin Halvorsen, extended heartfelt congratulations to the 13 new centres that were awarded funding in 2012. “Researchers who are seeking a role at the cutting edge of their international fields need flexible, long-term funding to give them a chance to take bolder steps,” said Halvorsen.

“All our experience indicates that these 13 new centres will deliver research that makes a lasting impact for years to come. They are already well-established research groups; this long-term funding gives them the chance to make their mark at the forefront of international research,” said Arvid Hallén, Director General of the Research Council.

“This is a big day for NTNU. We are very happy and proud that all four of the NTNU applicants who were finalists were also selected to be Centres of Excellence. This is an important recognition of the quality of the research that is conducted at NTNU,” said Kari Melby, NTNU’s Pro-Rector for Research.

The four new CoE units awarded to the NTNU in 2012 were:

- Centre for Autonomous Marine Operations and Systems (AMOS)
- Centre for Molecular Inflammation Research (CEMIR)
- Centre for Neural Computation (CNC)
- Centre for Dynamics of Biological Diversity

The first three Centres of Excellence in Trondheim were inaugurated on 18 November 2002. From the left: Professor Peder Emstad of the Centre for Quantifiable Quality of Service in Communication Systems, Professor Edvard Moser of the CBM, Professor Torgeir Moan of the Centre for Ships and Ocean Structures, Christian Hambro, Director of the Norwegian Research Council, and Kristin Clemet, Minister of Education and Research. (Photo: Rune Petter Næss, NTNU Info).
NTNU
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, 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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