Annual Report 2017

KAVLI INSTITUTE FOR SYSTEMS NEUROSCIENCE

Norwegian Centre of Excellence

THE KAVLI FOUNDATION

NTNU
Norwegian University of Science and Technology

To understand the emergence of brain functions in any system in any species

Our Vision

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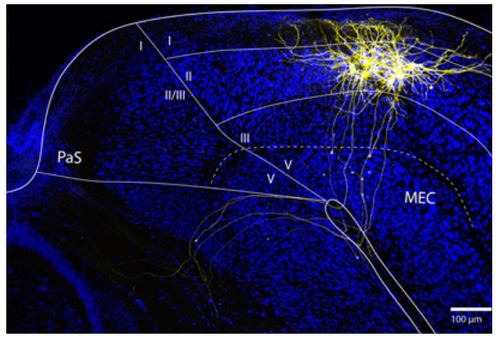
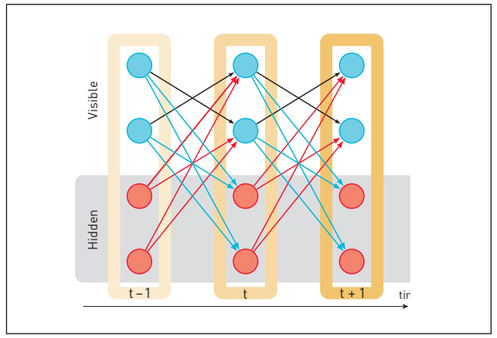
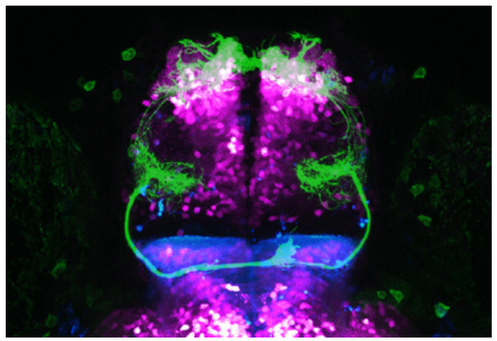
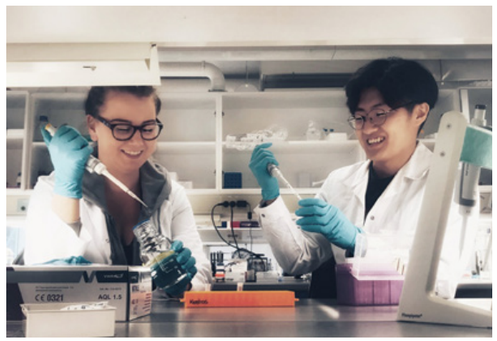








A New Era at Kavli Institute for Systems Neuroscience, NTNU

Long before the existence of the Kavli Institute for Systems Neuroscience (KISN), the core research groups brought together by Drs. May-Britt and Edvard Moser was known as the Centre for the Biology of Memory. In those days, explains Dr. Edvard Moser, "there was no distinction between the administrative side of things and the scientific side." The year 2017, a decade after the CBM inherited the Kavli name, this distinction has been made more clear. With the hire of Rannveig Tellemand Storeng as the new Managing Director of KISN, the institute is now divided along clear administrative and scientific lines. "I think it's been a necessary transition as a result of the growth of the institute," says Dr. Edvard Moser; "there came a point where it wasn't possible to do it all."

The institutional level changes are happening at the same time as the field of neuroscience is itself undergoing big changes. "The technology is changing quite substantially," says Dr. Edvard Moser. Whereas scientists were previously recording from no more than dozens of cells at a time, new technologies, such as silicone probes and high resolution microscopy are now making it possible to record from hundreds to thousands of cells at once. Finally, while the focus on the basic research questions (such as, *how does the brain create memories?*) remains the same, there is also a newfound focus on using this knowledge to better understand diseases such as Alzheimer's.

Finally, the institute is hoping that by making data at KISN publicly available, it can be used by any other research team in the world. To do this well, the data must be first organized and sorted so that it is interpretable, meaningful and ultimately useful to groups outside of KISN. "We are hoping to make good progress on that by the end of the year," says Dr. Moser.

COMMUNICATING SCIENCE TO THE PUBLIC

For the Kavli Institute for Systems Neuroscience, 2017 was more than just a year of organizational and structural change. It was also a year with great strides towards efforts at effective and clear science communication. Throughout the year, a series of educational videos was created to highlight research at the center. In June of 2017, NTNU, Starmus and KISN co-organized a science festival which featured public lectures and panel discussions across various scientific fields. The KISN leaders agree that these efforts were successful and hope that this is just the beginning.

In 2017, our Centre of Excellence, CNC, was visited by an interdisciplinary, international evaluation committee appointed by the Research Council of Norway. CNC received an excellent midterm evaluation. Based on this, the RCN decided to continue the funding of research for another 5 years. Without the many years of support from the Research Council of Norway, we would not have two Nobel Laureates heading an internationally leading research centre in Trondheim today.

"The science as well as the communication of our centre is of very high quality. At least nationally, I would say that the science communication we do here at the centre is at the front, both in regards to innovation, and in the way we reach out broadly through various media formats and platforms,", says Rannveig Tellemand Storeng.

"Efforts for communication is currently underfunded," says Dr. Edvard Moser. "We see the importance of it, and we see how much we could do. At the same time we see how much work it requires, so we need the resources to expand in this field. For example, when it comes to illustrating difficult scientific concepts effectively, videos are an effective tool, but "that doesn't come for free," he emphasizes, "it takes a lot of work just for a single minute of video creation."

"We have to acknowledge that science communication is a profession", explains Rannveig Tellemand Storeng. "If we want to reach out to the public well and take it seriously, we need professional science communicators. You can't do this on your own as a scientist. I think that we have to acknowledge this and take it seriously and step up on our financial support."

Overall, the centre's science communication goals are twofold: (1) share the research findings and scientific facts themselves, and (2) share more about the scientific method and the *process* of "doing" science. Dr. Edvard Moser explains it's important for the public to understand why scientists would pursue research in the first place and "why you should trust scientific data more than other kinds of information. In the end, it's part of a bigger effort that is related to the foundation of democracy. This is a vision we share along with the scientific vision."

Not only is it related to democracy and the health of a society overall, it is, in the eyes of the institute leaders, a responsibility to give back to those who have funded efforts so far. "We recognize that we are quite generously funded from the government and the university and we see that it is our obligation to invest that funding into communicating what it is that we do here," Rannveig Tellemand Storeng says.

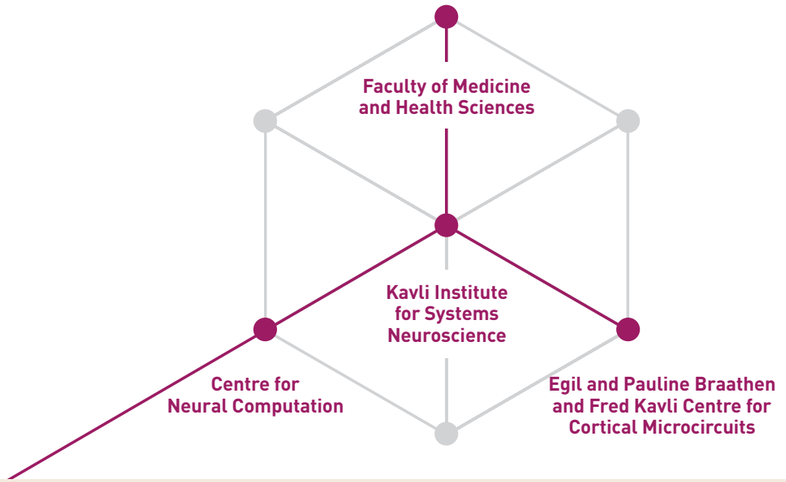
"I think that has been my vision from the start of the whole thing; we want to be a paragon for the rest of the world. The star, in the end, is excellent science. But on the way to excellent science there is much else that is extremely important," says Dr. May Britt Moser. However, unlike funding for veterinarians or research tools, there is no formal budget allocation that is typically set aside for high quality science communication. When the Moser team requested funding for this effort, they were initially met with skepticism. By creating formal positions, however, you are not only streamlining the work within your own institute, you are signaling to the world outside what it is that you value as an organization, says Dr. May Britt Moser. And at KISN, the values remain clear: "We care about our animals, we care for our people, we care about our science and we also care about our communication with the public."

May-Britt Moser

Edvard Moser

Rannveig Tellemand Storeng

Organisational chart



GROUP LEADERS

MAY-BRITT MOSER
Moser Lab

EDVARD MOSER
Moser Lab

MENNO WITTER
Witter Lab

JONATHAN WHITLOCK
Whitlock lab

YASSER ROUDI
Roudi Lab

CLIFFORD KENTROS
Kentros Lab

EMRE YAKSI
Yaksi Lab

CHRISTIAN DOELLER
Doeller Lab

RANNVEIG TELLEMAND STORENG
Managing Director

A starry beginning

BACKGROUND

Although neuroscientists know that spatial cells in the brain are important to generating our sense of space, less is known about how these cells work in a network to make this possible. While the Moser group continues to identify and characterize different spatial cell types, they are also actively researching how these cells work together in a circuit to create our sense of space, our ability to remember, and cognition in general.

KEY RESEARCH QUESTIONS

- How does the brain compute space, and what can this computation tell us about cognition in general?
- How do specific types of space cells (grid cells, place cells, head direction cells, border cells, etc) work together to create our sense of space in the world?

TOOLS & METHODS

In order to understand how space cells work together, you need a tool that can record from several of those cells at the same time. In the past, this wasn't technically possible; neuroscientists relied mostly on electrodes that could pick up electrical signals from individual neurons one at a time. However, with the advent of the latest technologies, it is now possible to pick up those electrical signals from hundreds of neurons simultaneously, while still preserving the unique signal from each one neuron. This is made possible by gently inserting high-site-count silicone probes - ultra thin probes with many hundred recording sites - into the brain. Additionally, the group uses a technique called 2-photon imaging in which miniature microscopes can record and visualize the activity of hundreds up to thousands of fluorophore-expressing neurons within a chosen field of view, at once. Because these microscopes are so small and light (only 2 grams), the mouse can effortlessly balance it on the head while continuing with its natural exploratory behavior. This is important because it allows scientists to determine what neuronal signals are meaningful for natural behavior.

Finally, it is not only the tools themselves that have been updated, but the environments in which the animals are allowed to explore. The seminal experiments which were important for laying the foundation of spatial coding and navigation relied on data from animals exploring simple, empty boxes. The Moser group is now collecting data from animals in more realistic environments - such as a space where locations can be inferred from configurations of objects, for example. Together, all of these methods will bring us one step closer to understanding how the brain codes for space in the most realistic of settings.

RESEARCH IN 2017

The brain represents space using a variety of cells, which code for specific dimensions of navigating the environment such as edges, location, direction, speed, etc. These cells are found in two interconnected areas of the brain: the hippocampus and the entorhinal cortex. Previous work

First Row from Left: Sebastian Ola Andersson, Abraham Zelalem Vollan, Ingvild Ulsaker Kruge, Valentin Normand, Ragnhild Irene Jacobsen, Giulia Quattrocolo, Soledad Gonzalo Cogno, Anne Nagelhus, Kamilla Gjerland Haugland.
Second Row from left: Richard Gardner, Jan Sigurd Beddari Blackstad, Øyvind Arne Høydal, May-Britt Moser, Torgeir Waaga, Flavio Donato, Klaus Jenssen, Maria Mørreaunet, Ann Mari Amundsgård, Edvard I. Moser, Rita Elmkvist Nilsen.
Third row from left: Vadim Frolov, Horst Obenhaus, David Clayton Rowland, Nenitha Charlotte Dagslott, Martin Hägglund, Endre Kråkvik, Kyrre Haugen, Tor Grønbech, Jørgen Sugar. Also in the group but not present when the photo was taken: Miguel Carvalho, Nouk Tanke, Debora Ledergerber, Tale Litleré Bjerknes, Torstein Slettmoen, Emilie Ranheim Skytøen, Tora Bonnevie.

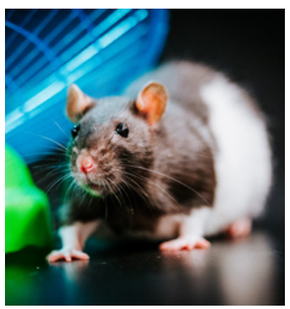
from the Moser team showed that while some of these cells are mature almost from birth (i.e. they immediately code for place or edges), other cells (like grid cells found in medial entorhinal cortex or MEC) mature more slowly out into adulthood and develop a specific spatial code over time. Perhaps, the team then reasoned, this parallels the slow development of the subregions of the hippocampus and entorhinal cortex. Indeed, this is exactly what Flavio Donato, a postdoctoral fellow in the Moser lab, discovered, together with his collaborators. The findings were published in the journal Science in early 2017. "He found," says Dr. Edvard Moser, "that the subregions of the hippocampal and entorhinal cortex system develops in a staggered way." The very first cells that set the stage for this course of development? A set of cells deemed stellate cells so named due to their starry like appearance. The stellate cells, Moser explains, is where the majority of grid cells reside before they mature. Importantly it is these cells that enable the maturation of other subregions of hippocampus and the entorhinal system. "Now that Donato has developed these tools to tag cells at different embryonic ages, you can follow them throughout their lifespan, to study their other properties, and turn them on or off for experimental testing."

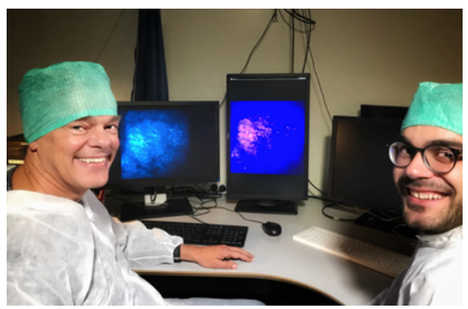
Additionally, the group has some unpublished findings and projects they are working on. While the encoding of space is very well characterized, our understanding of how the brain encodes for time is less well understood. However, time is an important part of memory; when we recall narratives of our lives, we remember not just where something happened but when it happened. Thus, with Albert Tsao, a former PhD student in the group, the team is currently investigating cell populations in the lateral entorhinal cortex (LEC) to see if this region plays a role in the processing of time. Finally, says Moser, the team, with PhD student Øyvind Høydal as the key contributor, has recently discovered yet another type of spatial cell in the medial entorhinal cortex (MEC), which codes the position of objects in space, called object vector cells.

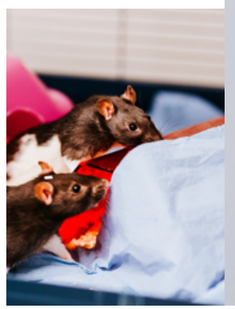
All of these findings may make it seem that the Moser team is committed primarily to investigating how the brain represents and processes space and time. While, on its own, this is an interesting question, Moser explains that it is not the end goal: "We use space as a window into the brain since space it is relatively simple and easy to measure, then maybe we can find more general codes that perhaps are applied all over the brain, for a variety of functions." In other words, the code for space might teach us, also, about the brain's code for decision making, abstract thinking, planning, and so on. The more we understand about how the brain generates mental processes such as these, the better poised we are to answer questions about what goes wrong in the brain when these processes break down. "This relates specifically to psychiatry which is often the result of disordered cognition," says Moser, "Since we have a limited understanding of cognition, the basis for treating these diseases is still very poor. I think our research on fundamental cognitive operations is a gateway for treating psychiatric diseases."

AIM

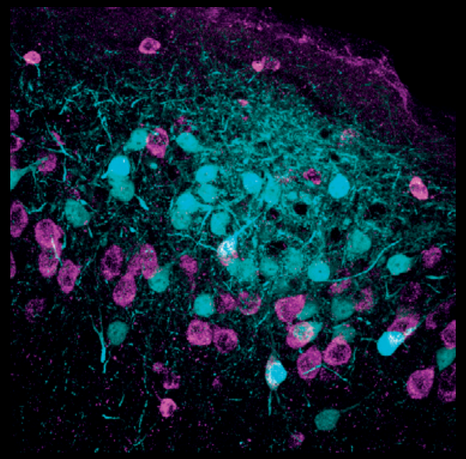
Understanding how the healthy brain codes cognition will allow us to better understand also the diseased brain, and to treat psychiatric disorders.



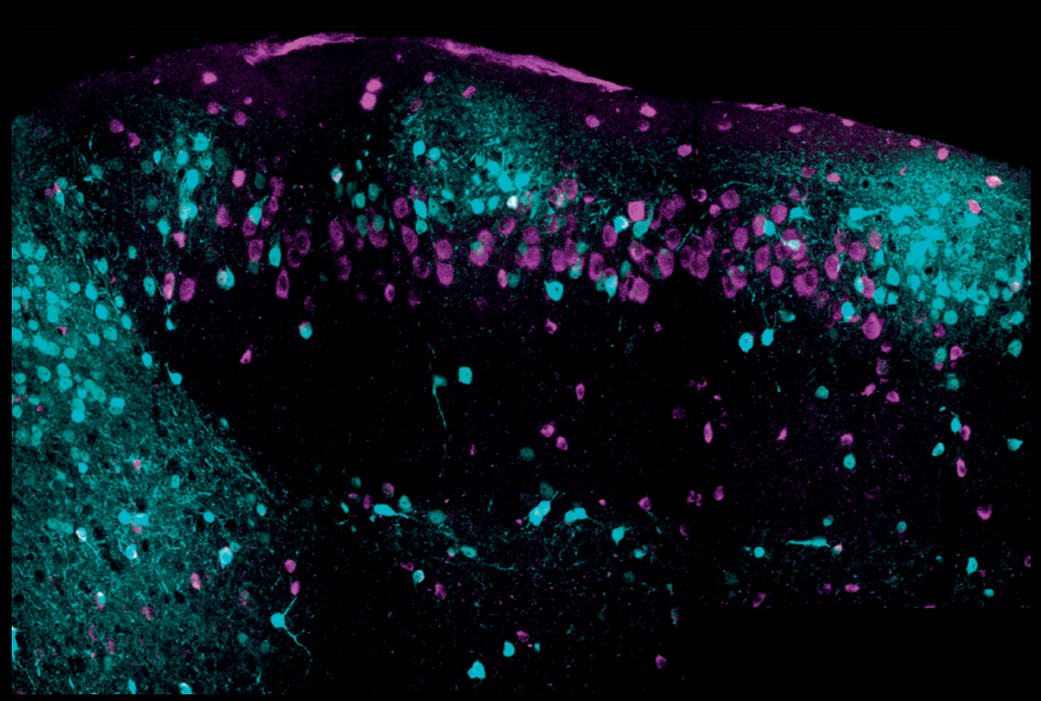


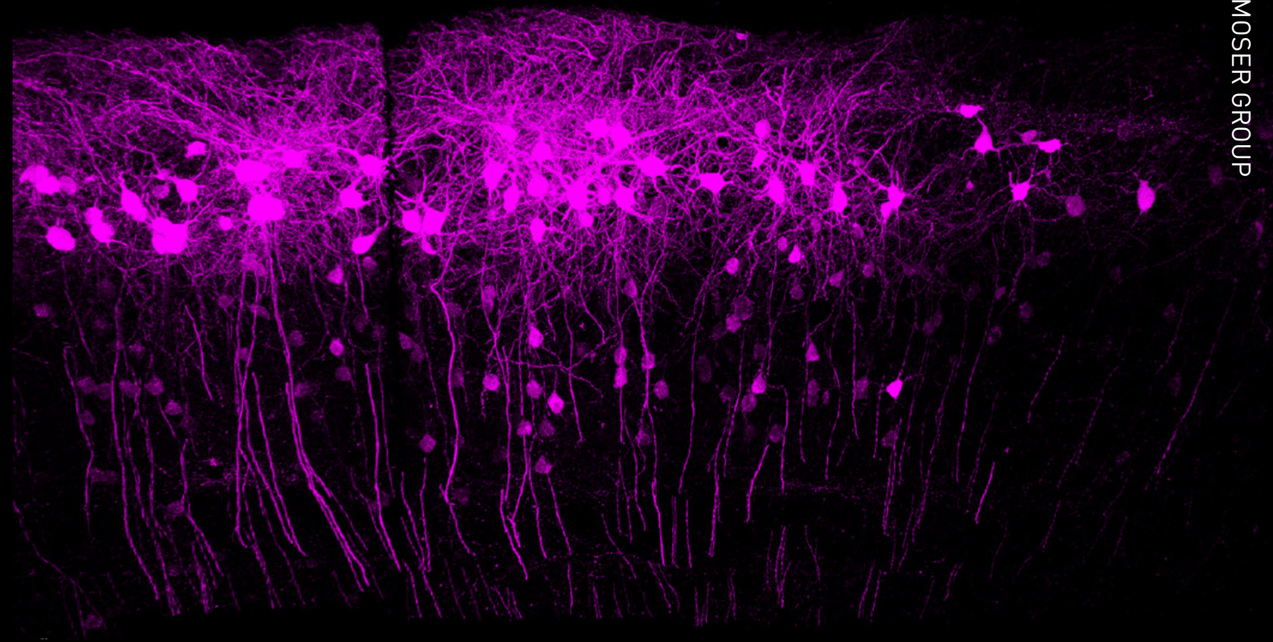


Right: Immunological detection of stellate and pyramidal cells in layer 2 of the medial entorhinal cortex. The two cell classes can be distinguished because of the differential expression of the protein Reelin (magenta, expressed by stellate cells) or Calbindin (cyan, expressed by pyramidal cells). Specific antibodies raised against these two proteins allow for the simultaneous visualization of both cell classes in the same fixed sample.
The image is the maximum intensity projection of a 50um stack imaged with a confocal microscope, generated by Flavio Donato, Moser Group.

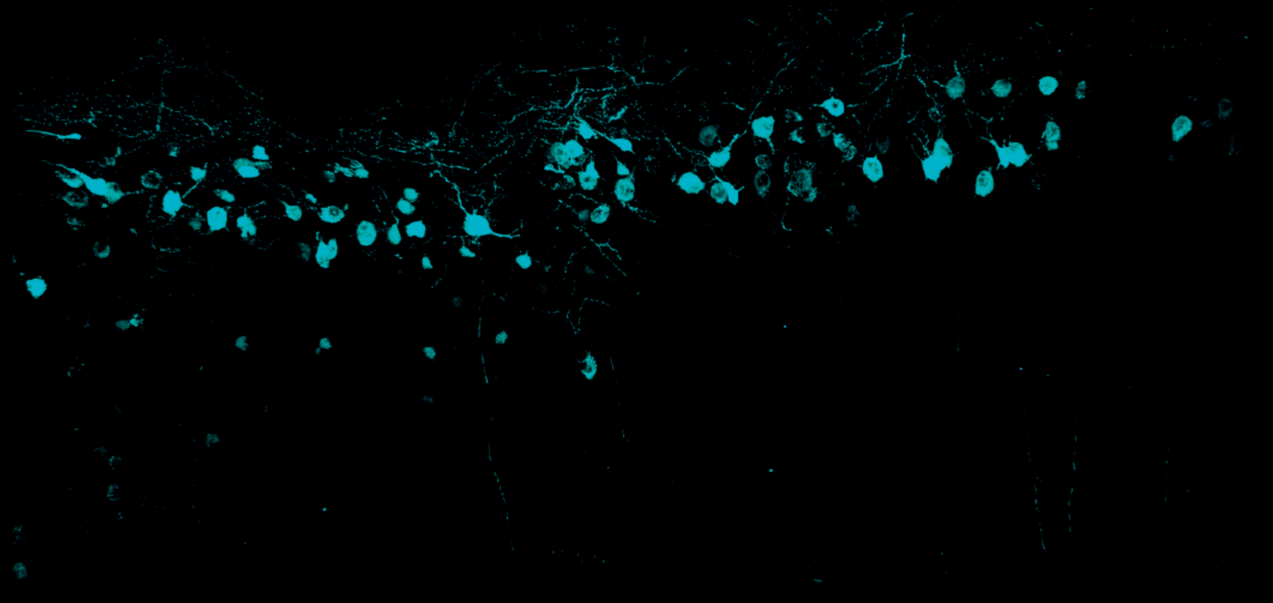


Below: Anatomical organization of stellate (magenta) and pyramidal (cyan) cells along the dorso-ventral axis of the superficial layers of the medial entorhinal cortex (dorsal MEC-POR border on the left). Notice how groups of tightly clustered pyramidal cells are interspersed among largely un-clustered stellate cells.
The image is the maximum intensity projection of a 50um stack imaged with a confocal microscope, generated by Flavio Donato, Moser Group.





Viral labelling of neurons born on the same day (i.e., "isochronic") during embryonic development. Cortical neurons were labelled based on their birthdate by injecting a viral vector carrying a genetic tag in the ventricle of the developing pup´s brain. The genetic tag allowed for the visualization or manipulation of isochronic neurons at later stages of the animal´s life. The image above shows neurons born early during development, which are predominantly stellate cells. The image below shows neurons born late during development, which are predominantly pyramidal cells. The images are the maximum intensity projection of a 50um stack imaged with a confocal microscope, generated by Flavio Donato, Moser Group.



BACKGROUND

Like pieces of a puzzle, the brain is made up of distinct areas with specific functions. One general approach neuroscientists, and particularly neuroanatomists, have taken to understanding the brain is to relate the architecture of these different brain areas to their function. On a large scale, we understand what different brain areas do. On a smaller scale, however, where details of the cell types, genes, and circuitry come into play, the picture is not as clear. Using the latest tools, Witter and his team are hoping to unravel the functional differences between medial and lateral entorhinal cortex, based on the architectural differences between them.

KEY RESEARCH QUESTIONS

- Do underlying architectural differences between the lateral and the medial entorhinal cortex explain why they function differently?
- What role does the protein reelin, found in the entorhinal cortex, play in the development of Alzheimer's pathology?

TOOLS & METHODS

To answer these questions, Witter's research team identifies, visualizes and finally manipulates entorhinal cortex cells and the connections between them. To do this, they use genetically engineered animals and/or non-infectious viral tracers, which can be used to fluorescently visualize specific cell types within the entorhinal cortex. Once the cell types and connections are identified, they use a technique called optogenetics to turn specific cells on and off with laser beams and then study the effect of this perturbation on the rest of the circuit.

RESEARCH IN 2017

An anatomist at heart, Witter hypothesized that the functional differences between the medial and the lateral part of the entorhinal cortex might be explained by architectural (or anatomical) differences between the two. However, he and his team were surprised to find that the two areas were not as different as they had guessed. "I was convinced that this was an obvious thing to expect and I was really surprised that they were not that different," says Witter. While the internal anatomical circuitry between medial and lateral entorhinal cortex is strikingly similar, specific cell types in the two areas have connections to very different parts of the brain. This, postulates Witter, may better explain some of the functional differences observed between the two regions.

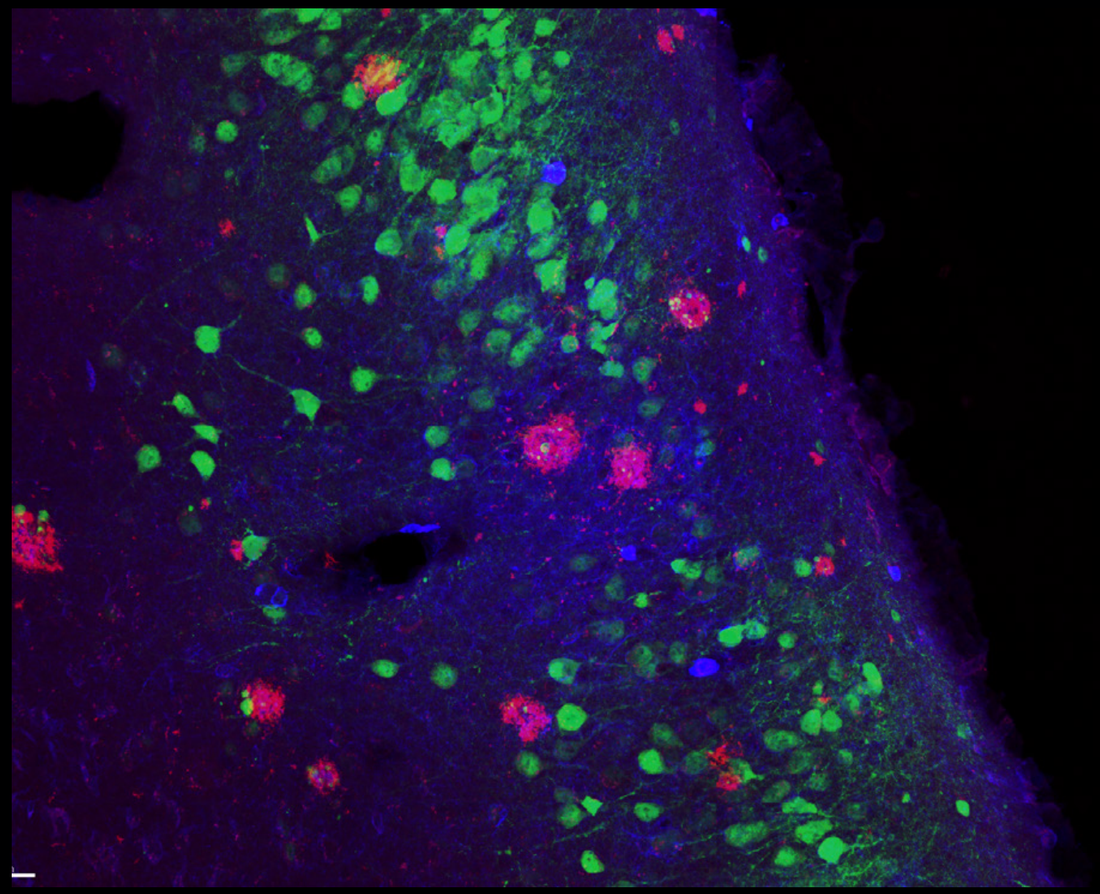
One example of why it is important to consider the differences in structure and function is well illustrated by the group's work on Alzheimer's research. Witter explains that specific cell types within a particular part of entorhinal cortex called "layer two" are the first to be affected in Alzheimer's pathology. Using genetic engineering tools described above, they are able to identify and manipulate these and other cells in layer two to study their properties. "The results so far are promising," says Witter, "and the translational potential of this research is much greater now that we have a better understanding of the cell types and the differences between them." The team has already begun collaborations with other research groups across the globe, including Japan, Sweden, Finland, Denmark, and the United States. Witter remains optimistic that they are getting closer to a better understanding of the entorhinal cortex and its role in Alzheimer's disease. "I'm sure next year I'll be giving you even more details," he shares, "as we have already generated a lot of new data in recent months."

AIM

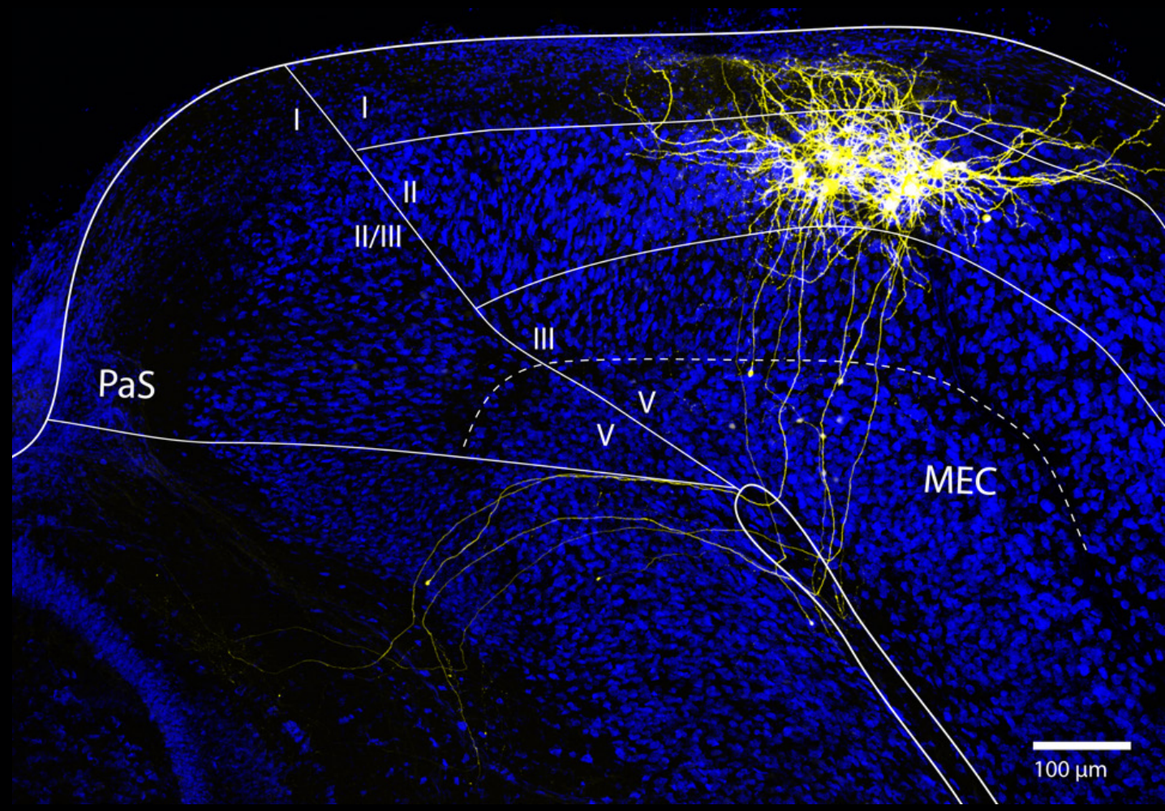
The entorhinal cortex is one of the first brain areas affected by Alzheimer's disease, so it is important to better understand its architecture and the function of all the neuron types within.

The relationship between brain architecture and function

First row from left: Eirik Stamland Nilssen, Tobias Bergman, Maria José Lagartos Donate, Hanne Tegnander Soligard, Bente Jacobsen, Grethe Mari Olsen, Paulo Girão, Peter Kovachich, Asgeir Kobro-Flatmoen, Maximiliano Jose Nigro.
Second row from left: Christiana Bjørkli, Bruno Monterotti, Shinya Ohara, Menno P. Witter, Tore Bryntesen Lund.
Third row from left: Arthur Laja, Thanh Pierre Doan, Kasper Kjelsberg, Laura Convertino, Katrine Sjaastad Hanssen. Also in the group but not present when the photo was taken: Erin Elisabeth Calhoun



Cells in the brain of a transgenic mouse model of Alzheimer's disease (APP/PS1). The image displays the part of the entorhinal cortex known as layer II. A viral vector (green) that inhibits the expression of reelin in reelin-positive layer II neurons (blue) has been injected, with the aim to study the effect of reelin expression levels on amyloid-beta 1-42 (red). Confocal microscopy image generated by Christiana Bjørkli and Asgeir Kobro Flatmoen, Witter Group.



Six stellate cells in layer II of medial entorhinal cortex. The image shows cells that were in vitro patch-clamp recorded and filled with biocytin (yellow), together with a Nissl stain (blue). Visible are the characteristic multipolar dendritic trees in layers I and II as well as the main axon (shooting downwards), leaving the entorhinal cortex through the adjacent white matter, entering and perforating the subiculum, on the way to the hippocampus. Confocal Image generated by Eirik Stamland Nilssen, Witter Group.

The neural building blocks of behavior

From left: Benjamin Dunn, Tuce Tombaz, Karoline Hovde, Jonathan Whitlock, Andrea Marie Hegstad, Ece Gözde Demirci, Bartul Mimica. Also in the group but not present when the photo was taken: Bente Skei.

BACKGROUND

One of the main goals of neuroscience is to understand how brain activity generates behavior. As a point of entry into understanding this more generally, Whitlock's team is investigating how cell populations in the brain represent behavior in different contexts. As a systems neuroscientist, Whitlock's research team works to bridge the fundamental pieces of neural coding with the bigger picture behavior.

KEY RESEARCH QUESTIONS

- How do neurons in different brain areas work together to encode behavioral experience?
- How does the brain encode the natural movement of the body in three-dimensional space? What is the neural code for movement? *(i.e. does a single cell in a specific brain area encode one particular motion or do cells across different brain areas provide bits of information that are collectively used to encode motion?*

TOOLS & METHODS

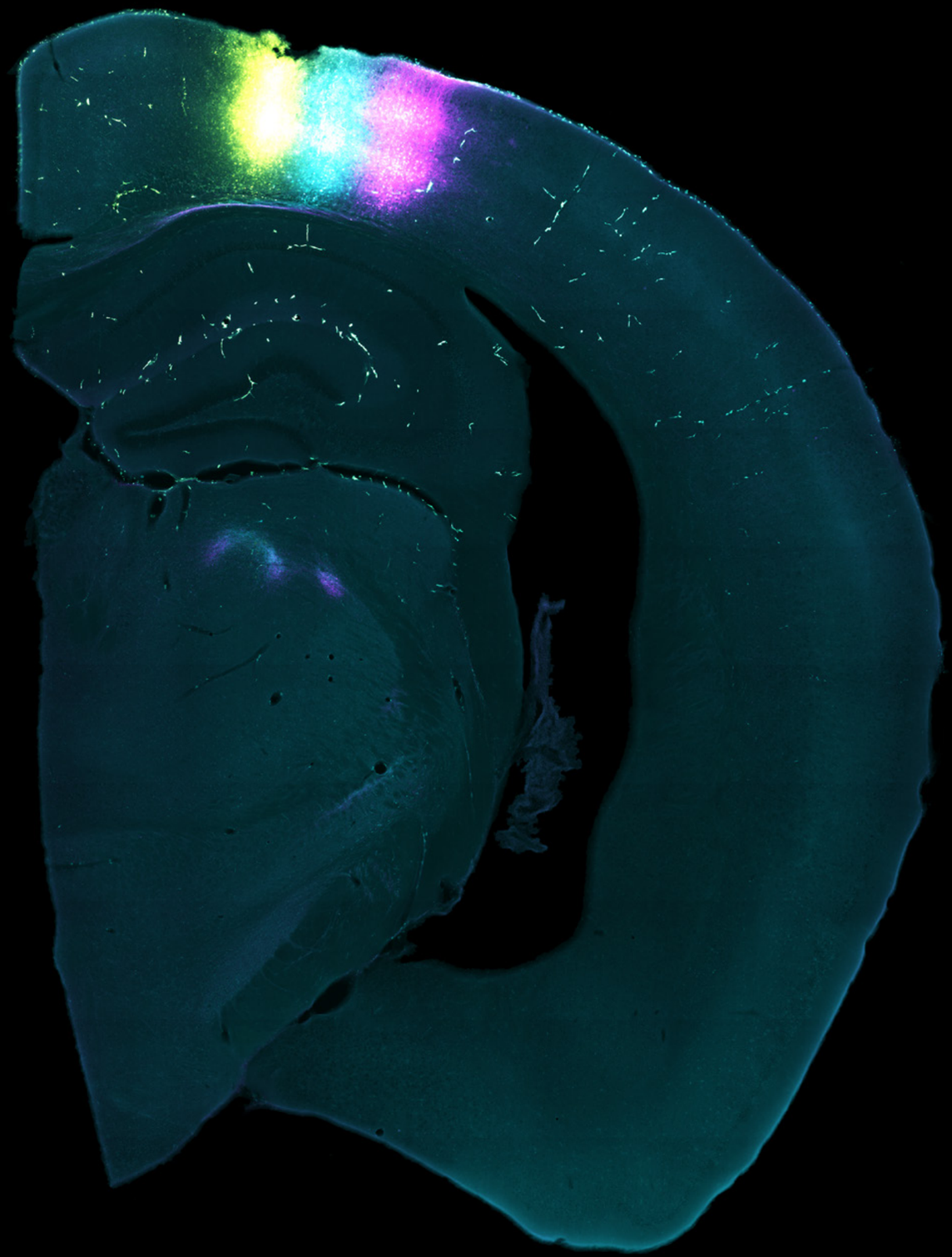
To answer this question, Whitlock's team records the activity of rat brain cells, whilst simultaneously tracking and visualizing a rodent's movement through three dimensional space. Next, the team analyzes the relationship between the rat's movement and its pattern of brain activity using statistical methods and machine learning.

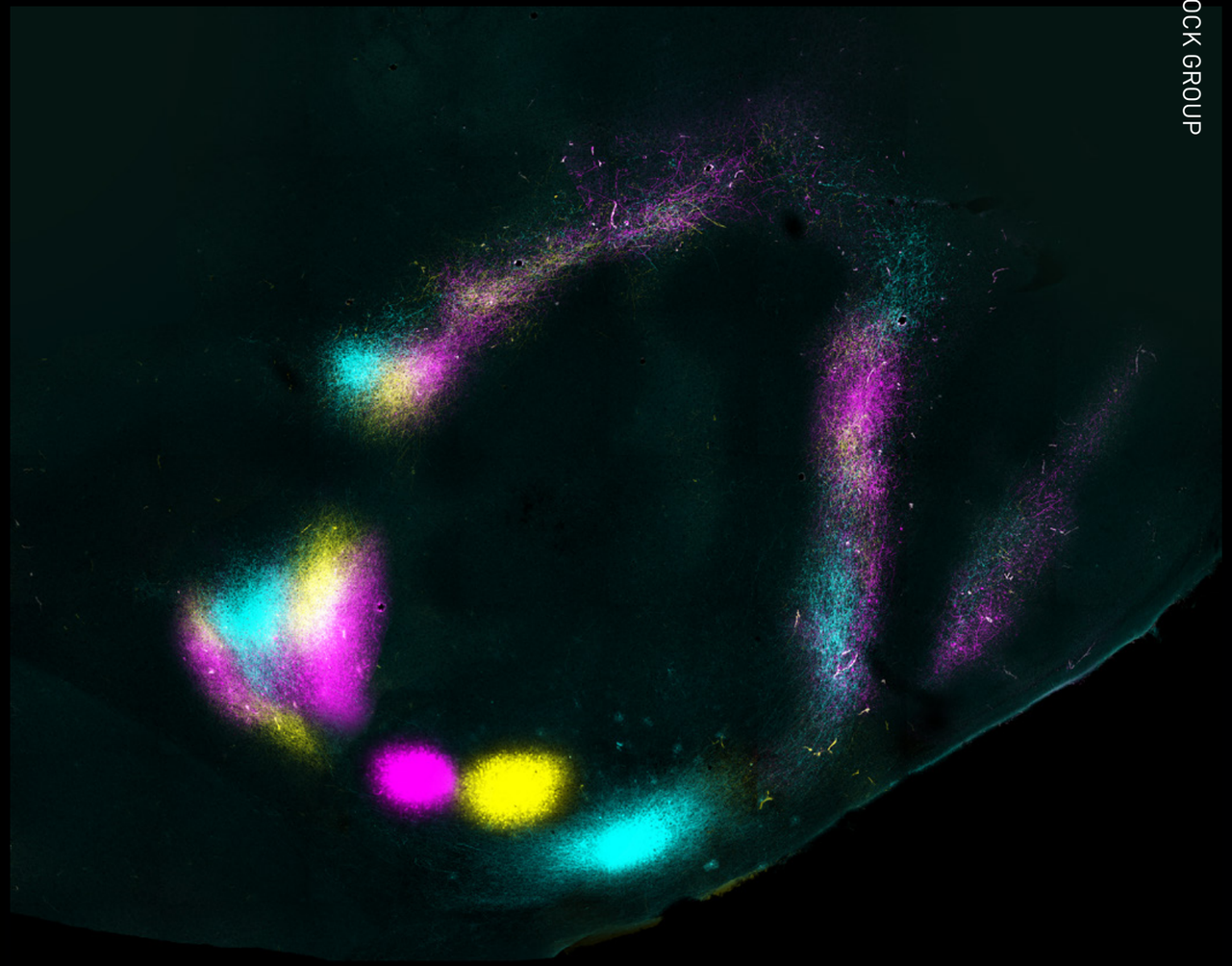
RESEARCH IN 2017

Rats are naturally curious creatures who enjoy actively exploring new spaces and if you observe a rat long enough, you'll witness a wide range of different movement patterns, such as rearing, grooming, sniffing, flicking the tail, arching the back, and so on. Each one of these movements is made possible by specific patterns of activity in the motor cortices - areas of the brain responsible for positioning the body and generating movement. For example, when a rat rears upward, a certain subset of cells in the brain "fire" in a particular timed pattern, signaling and ultimately generating that physical movement. When that same rat rears up and then to the left, however, that particular movement may be represented by a slightly different pattern of activity, and in a different set of cells. In fact, this is exactly what Whitlock's team discovered – that groups of cells are highly sensitive to specific postures, or "up and to the left" sensitive cells. "These cells just rip like mad," says Whitlock explaining that the signal is not only there but very strong and clear. Furthermore, using the neural spike timing activity, Whitlock explains that they are able to reconstruct the rat's posture in 3D space, confirming that these are meaningful brain signals. By continuing to observe, record, and catalog these various neural patterns, Whitlock ultimately hopes to discover how they are strung together, providing "the building blocks of behavior itself".

AIM

This research will help us understand the principles of neural activity that generate patterns of natural behavior.





Left: Three different anterograde tracers injected into posterior parietal cortex to study the connections with other brain areas. Image is generated by Karoline Hovde, Whitlock Group.

Above:
Projections of the primary visual cortex to higher order visual areas in the mouse. Image is generated by Karoline Hovde and Michele Gianatti, Whitlock Group.

Identifying informative cells in a sea of activity

BACKGROUND

As technologies are growing more sophisticated, neuroscientists are gathering larger and larger datasets with recordings from hundreds upto thousands of neurons at a time. On its own, this is not informative. However, together with a theoretician and some behavioral data, it is possible to extract some meaning from the neuronal signals.

KEY RESEARCH QUESTIONS

- What can global patterns of neuronal activity tell us about how the brain works? In a sea of active neurons, which ones are providing relevant information to their connected neurons?
- How much can the activity of a given set of neurons tell us about another neuron in that same network? How can experimentalists identify which neurons are "informative" within a sea of variably responding neurons?

TOOLS & METHODS

Roudi's team uses analytical tools from statistical mechanics, information theory and computer programming to develop models which can describe large datasets that are brought to him from other labs in the centre. Models, he explains, can help scientists generate better informed theories about the computations in the brain. "At the end of the day you want a simplified model of what processes are occurring in the nervous system," says Roudi.

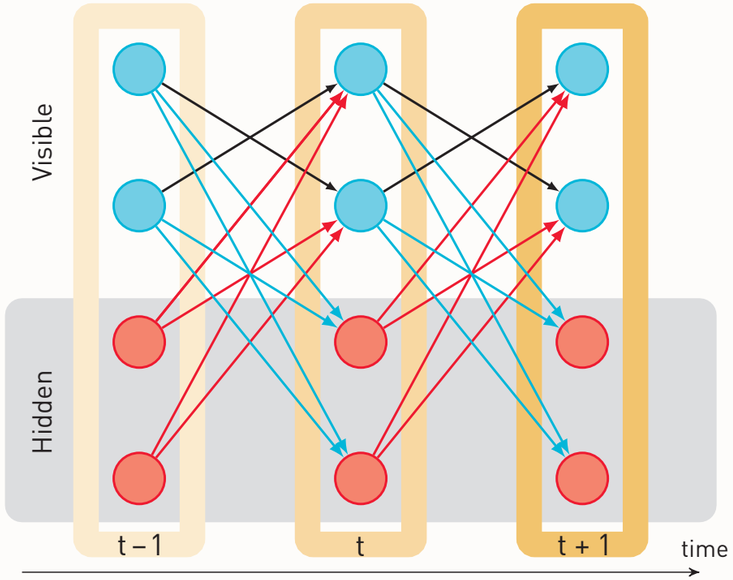
RESEARCH IN 2017

Experimentalists record a lot of data from neural activity in the brain, and need methods to discover patterns in the big data. Good statistical modeling will help infer and decode meaning from the hundreds of cells that are recorded in an experiment. Roudi is interested in knowing which neurons within a group or "network" of neurons are the important or "informative" for computation in a particular task. To do this, his team developed a model, which allows experimentalists to identify the informative cells amidst a sea of cells chattering with activity. Critically, the model does not set any assumptions about the network of cells beforehand but rather uses only information about when the neurons are active to extract meaning. This is important because it means the findings of the model are based more in the actual data itself and less in assumptions about the patterns and properties of the cells prior to observation. The model revealed the following finding: neurons with a wide range of firing activity – meaning they are responsive to many external stimuli – at various time points were more "informative" than neurons with a narrower range of firing activity. This was confirmed by applying the model and correctly predicting the rat's actual position or head direction in space.

AIM

This research will help experimentalists make informed decisions about how to design and analyze their experiments, saving them time and potentially leading them to novel discoveries about brain computation more quickly.

From left: Ryan John Abat Cubero, Yasser Roudi, Nicola Bulso, Claudia Battistin.



Hidden variables (e.g. not recorded neurons) are dynamically coupled to the visible (recorded) neurons and therefore affect statistical inferences on the visible network. Neural network model produced by Claudia Battistin, Roudi Group.

The relationship between the grid and the place cell code

BACKGROUND

Since their discovery, grid cells have generated a great deal of excitement among neuroscientists. While researchers agree there must be a link between the spatial codes, their relationship is still unclear. By using the latest technologies, the Kentros group unraveled some important information about the interplay between both cell types.

KEY RESEARCH QUESTIONS

- What changes in the brain when you learn something?
- How do spatial representations in entorhinal cortex - where grid cells reside, create or modify inputs from the hippocampus - where place cells reside?

TOOLS & METHODS

In order to figure out how two areas of the brain are dependent upon each other, you generally need two types of tools: one that can manipulate the normal pattern of neuronal activity and one that can record the effect of the disruption. Here, the Kentros team chose to manipulate the activity of grid cells in the medial entorhinal cortex (MEC) with a technology called "DREADDS" which stands for "Designer Receptors Exclusively Activated by Designer Drugs". As the name suggests, these receptors are activated only in response to a designer drug, which allows scientists to precisely control when they turn up or turn down the activity of cells. Then, to determine how this affects place cells in the hippocampus, they used electrodes and recorded the resulting activity. Scientists have long postulated that grid cells are responsible for the place cell signal, and if that's true, then disrupting one should disrupt the other.

RESEARCH IN 2017

One of the main inputs into the hippocampus comes from the entorhinal cortex. Because of this, when the Moser team made their Nobel-prize winning discovery of grid cells in the entorhinal cortex, many scientists conjectured that this signal was responsible for the generation of place cells found in the hippocampus. While place cells fire when the animal is in a specific place, grid cells fire in a tessellating "grid-like" pattern and from a mathematical standpoint, it was thought that if you line up and summate enough grid cell signals together, you could eventually generate a place cell. To test this idea directly, the Kentros team applied DREADDs to turn "up" or turn "down" the activity of grid cells in the medial entorhinal cortex (MEC) and simultaneously recorded from place cells in the hippocampus. Interestingly, when the DREADDs were used to turn up the activity of grid cells, in MEC, the place cells in hippocampus responded by changing their firing location (a process called "remapping"). This, however, was not the case when the DREADDs were used to turn down the activity of grid cells. "We basically figured, you tickle the same set of cells one way, you get remapping. You tickle the same set of cells the other way, you don't," said Kentros. Importantly, this was not just a strange artifact of the technology and the manipulation paralleled behavior nicely. When testing for spatial memory, rodents only showed impairments when grid cell activity was turned up (and place cells remapped), meaning that changes in these signals had meaningful impacts on rodent memory and behavior.

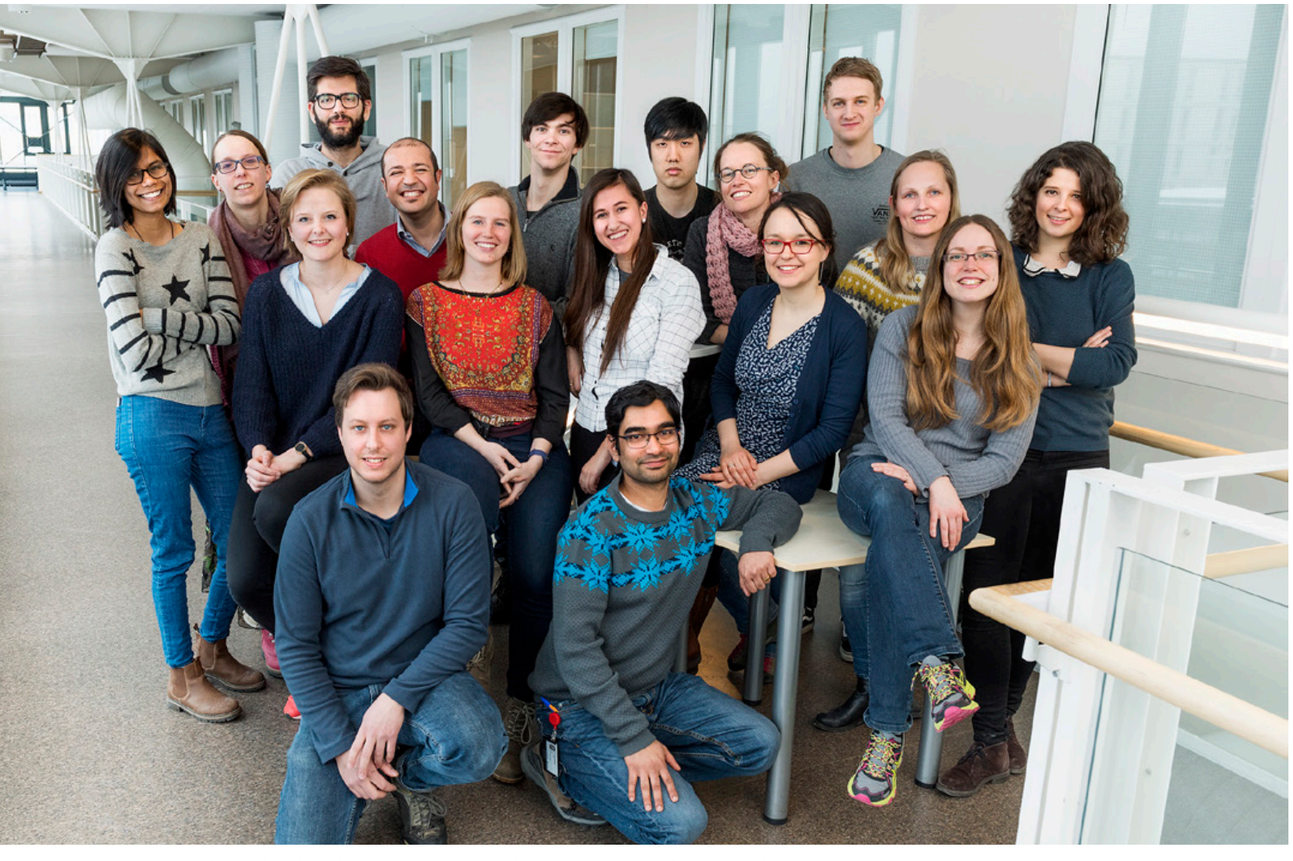
In the past year, the research group has also spent a great deal of time on generating new and improved tools for research. "It's becoming a separate part of the lab; the tool-making part of the lab," says Kentros. The most recently developed tool involves the use of enhancers – the bits of DNA that determine which genes are translated into proteins – to drive expression in specific cell types. This opens a whole new avenue for research, giving scientists more precise control over the brain circuits they are investigating. "This is the level of granularity at which the brain operates," says Kentros. Thus far, the tool seems to be working well in mice and collaborations with groups around the world are underway to move the technology into other species.

AIM

Understanding how the entorhinal cortex communicates with the hippocampus will deepen our understanding of spatial navigation and human memory and ultimately, this understanding will allow us to develop better therapies for when human memory breaks down.

From Left: Marcus Sandbukt Flatset,Dongkyun Lim,Dina Levi Juarez-Salinas, Thomas Doublet, Annika Utz, Joachim Schweder Grimstvedt, Annelene Gulden Dahl, Clifford Kentros, Christina Schrick, Christine Lykken, Benjamin Kanter, Qiangwei Zhang, Vilde Aamodt Kveim, Stefan Mattias Adriaan Blankvoort, Rajeevkumar Raveendran Nair.

Fish, flies and neural computations



First row from left: Robbrecht Pelgrims, Pradeep Lal. Second row from left: Emilie Willoch Olstad, Celine Deneubourg, Adinda Wens, Ewelina Bartoszek,Laetitia Lalla. Third row from left: Archana Golla, Daniela Weth-Malsch, Fabrizio Palumbo, Emre Yaksi, Vegard Fiskum, Taeyi You, Nathalie Jurisch-Yaksi, Henrik Østby, Merethe Andresen, Christa Ringers. Also in the group but not present when the photo was taken: Sverre Myren-Svelstad, Stèphanie Forè,Florence Kermen, Fredrik Rian, Andreas Moe Nygaard, Kevin Eriksen.

BACKGROUND

To discover fundamental principles about brain computation, it is important to use of simple model organisms in which the genetics have already been well defined. In this way, it is then possible to investigate how biology connects to natural behavior in both healthy and diseased brain states.

KEY RESEARCH QUESTIONS

- How is the sensory world represented in the animal brain and how does these computations regulate different behavioral programs.
- How are these representations modulated by behavioral states of animals.

TOOLS & METHODS

As a sensory neurophysiologist, Yaksi is interested in how our neuronal circuitry allows us to sense and perceive our outside world. His investigations focus on brain areas that integrate information from multiple sensory modalities and closely relate to behavior (e.g. telencephalon, habenula, brainstem). His group brings together principles of biology, fluid mechanics, and mathematics to answer the key research questions in two simple but equally elegant model systems: zebrafish and fruitfly. Because of their small scale and simple genetic makeup, both of these model organisms are well suited for studying the neural circuit computations both locally and across multiple brain regions simultaneously, and for asking fundamental questions of biological development and behavior.

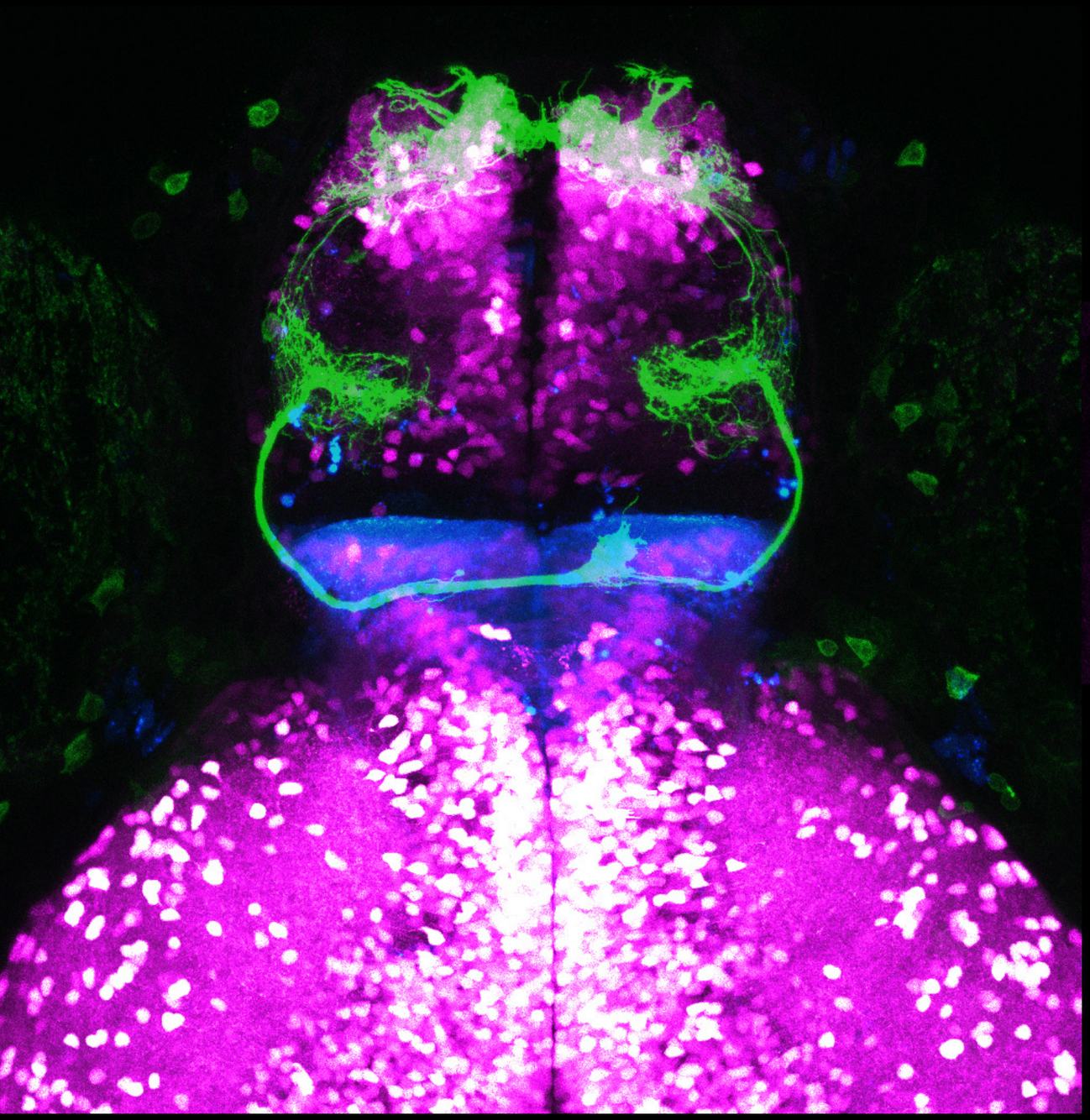
RESEARCH IN 2017

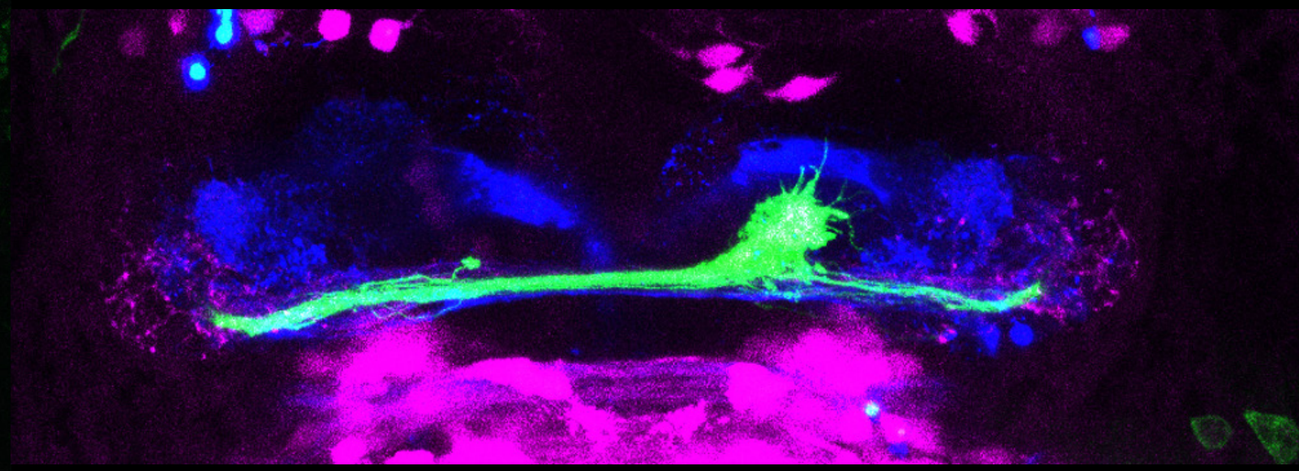
Fishy nose hairs as a model of neural computation
Zebrafish explore their aquatic environments using hair-like structures called "motile cilia". Yaksi found that these hair-like structures are organized in a neat pattern on the fish nose and beat with a consistent, pattern. This beating pattern causes the odor molecules in the water to flow into the nose of the fish, allowing the fish to smell. This is useful in still waters where there is no spontaneous flow of water and odor molecules into the fish nose. At the same time, the consistent beating pattern means odors clear out as quickly as they go in, which is useful for quick detection of odors when fish are exploring turbulent waters. This simple action of smelling, serves as a great model of neural computation.

Disrupted brain signals in fruit fly model of Fragile X Syndrome
Fragile X Syndrome (FXS) is a genetic condition, which leads to intellectual disability and behavioral disruptions. Some neuroscientists suggest that this results from alterations in the normal circuitry of the neurons. Specifically, the disruption is thought to exist in the connections of "inhibitory" neurons which act as a braking signal onto connected excitatory neurons. Yaksi's team confirmed this hypothesis by looking at the brains and behaviors of fruit flies. They found that flies with FXS were not able to discriminate odors as well as healthy flies and that this deficit was the result of disrupted inhibitory connections in the FXS fly brains.

AIM

Using simple model organisms it is possible to efficiently identify the relationship between brain circuitry and behavior.





The brain of a 6-day old zebra fish viewed from above. Here we study the supply of nerve fibers (called innervation) to functionally connect the structure habenula (in the white square) to different sensory areas (top). The olfactory bulb (green) carries olfactory information and innervates habenula asymmetrically. The thalamus (blue) carries visual information to habenula symmetrically (bottom). Throughout the development of the fish, we also observe inhibitory connections reaching habenula (pink). We are currently studying the formation of these connections and how they influence activity in habenula within different stages of development. In vivo confocal microscopy image is generated by Stèphanie Forè, Yaksi Group.

Mental mapping with the grid cell code

BACKGROUND

While the importance of the grid cell code in physical navigation is well established, its use in mental navigation, rehearsal, or imagination is not as clear. Doeller is investigating whether the same grid-like computations used by the brain to navigate physical space are used for the navigation of abstract space through the creation of mental maps.

KEY RESEARCH QUESTIONS

- What coding mechanisms does the brain use for cognitive processes such as memory and decision-making?
- Does a grid-like signal exist when participants search a visual scene with their eyes?

  Are disrupted grid-like signals in the entorhinal cortex good "biomarkers" for Alzheimer's disease?

TOOLS & METHODS

Doeller's research group uses two main tools: functional magnetic resonance imaging, or fMRI, and magnetoencephalography or MEG. The former allows for a noninvasive large-scale view of activity across the entire brain. The latter gathers precise information about the timing of brain signals. In combination, these two tools can yield important information about the where and when brain signals occur. Finally, the group uses high-resolution eye tracking tools to study behavior, such as virtual navigation, visual search and decision-making tasks, with the hopes of relating this behavior to the recorded brain signals.

RESEARCH IN 2017

Unlike the parts of the brain that respond directly to sensory information (i.e. signals from the outside world), the entorhinal cortex - where grid cells reside - receives signals from inside the brain. Specifically, "the signals come from centers we know are important for higher cognitive function," says Doeller. This, among other qualities, makes the grid-coding regime a likely candidate for the representation of abstract space. Indeed, fMRI and MEG evidence from the lab suggests that a grid like signal exists during the exploration of a visual scene. Specifically, the experiment revealed that grid like signals encoded gaze direction.

In addition to being important for the exploration of a visual scene, Doeller suggests that grid-like signals are used for the creation of cognitive maps to guide future decision-making. In other words, the same coding scheme that is used for the mapping of physical space is used to map abstract space, or mental maps. Indeed, the space in which we make decisions, though invisible to the outside world, exists very similarly inside of our brains. According to Doeller, the brain uses these "map-like" computations to make sense of previous experiences and to guide future decisions.

Finally, if this grid-like signal is indeed important for giving memory an actual structure and organization under healthy and normal conditions, its breakdown is then likely to predict pathologies of memory such as Alzheimer's. By understanding the basic mechanism, then, the hope is to better identify biomarkers that can predict pathologies.

AIM

This research will help us understand how the grid cell signal contributes to cognition, and help us make predictions about how and whether this signal break down in diseases, such as with Alzheimer's disease.

First row from left: Lilith Sommer, Dörte Kuhrt, Bianca Somai, Annelene Gulden Dahl, Gøril Rolfseng Grøntvedt, Tobias Navarro Schroeder, Britt Veldman. Second row from left: Christian Doeller, Joshua Julian, Mona Gravert, Matthias Nau, Renil Mathew, Ignacio Polti, Markus Frey, Jacob Bellmund. Also in the group but not present when the photo was taken: Dina Hestnes, Anne Merethe Winther.

10 YEARS AS A KAVLI INSTITUTE

– *In memory of Fred Kavli 1927-2013*

Fred Kavli had an unwavering faith in humanity. He held two core beliefs when it came to science: The first, was the importance of basic science and investing for the long run. Investing in basic research on the big questions could lead to great advances in the future, improving coming generations' ability to overcome the challenges of today.

The Kavli Foundation provides unrestricted funds, which are indispensable in discovery science. Fred's first visit to our lab was in 2005. This was the same year we had made our break-through discovery of the grid cell. I remember very well his curiosity and infectious enthusiasm about the data May-Britt and I showed him. We found common ground for our discussions in the application of ideas from theoretical physics to the model.

Fred's second core belief was the importance of sharing science with the public. Fred regarded knowledge as a means for the betterment of humanity. He was convinced that the best investment a country could make went into research and education for the population. His words had a profound impact on May-Britt and me, motivating us to reflect upon how to present research in a way that would invite all citizens to engage with our discoveries.

Fred had a sense of wonder about life and philosophy that he credited to his formative years growing up in Norway. There was a sense of kinship from our very first meeting. We came from similar backgrounds. Fred grew up in a remote village on the western coast of Norway, just like May-Britt and I had. None of us were raised in academic families. Even though he had lived for decades in America, it was clear for us that Norway remained dear to Fred throughout his life. He had put great effort into designing his California home, decorated with art and memorabilia from his childhood in Eresfjord and his youth in Trondheim. When visiting him in California we brought brown cheese and svele, a pancake dish served primarily in ferry cafés along the West coast of Norway which Fred was very fond of. In fact, he switched back to a 1950's version of his "Romsdal" dialect whenever we got together.

In 2008, he received an honorary doctorate, Doctor Honoris Causa, from his alma mater the Norwegian University of Science and Technology, in recognition of his work to the benefit and advancement of science and research. In the last few days before he died, he decided he wanted to be buried in Norway, to return to his roots.

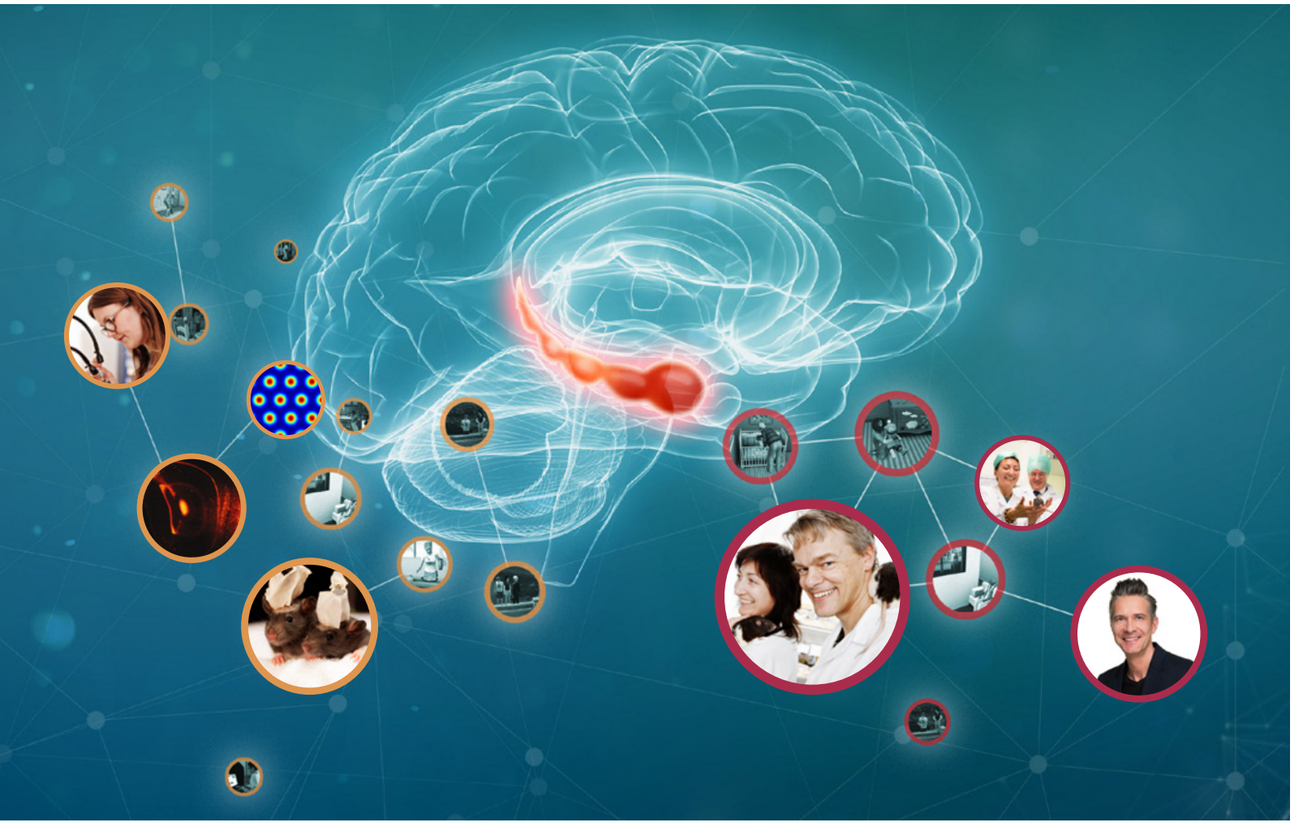
Edvard I. Moser

EGIL AND PAULINE BRAATHEN AND FRED KAVLI CENTRE FOR CORTICAL MICROCIRCUITS

The mission of our new research centre is to bridge the neuroscience lab with the Alzheimer clinic by translating promising results from basic research on animals to humans, and from the healthy to the diseased brain.

Locally, the research activities at the centre are performed in close collaboration with St. Olav's Hospital. Nationally, the centre is part of a network including hospitals, research facilities, patient organizations and other relevant stakeholders. The network is established to implement a national research agenda on prevention, diagnosis, treatment and care of people with dementia, with the aim of strengthening research capacity on national priorities for research into dementia in a sustainable and cost-effective manner.

We need to continue developing our corpus of knowledge about the brain, while at the same time making new knowledge from research available for patient treatment in the clinic.

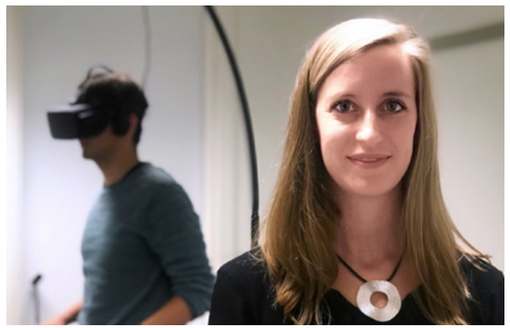


TRANSLATIONAL NEUROSCIENCE:

bridging layers of knowledge

Christian Doeller
Director of the Braathen/Kavli Centre

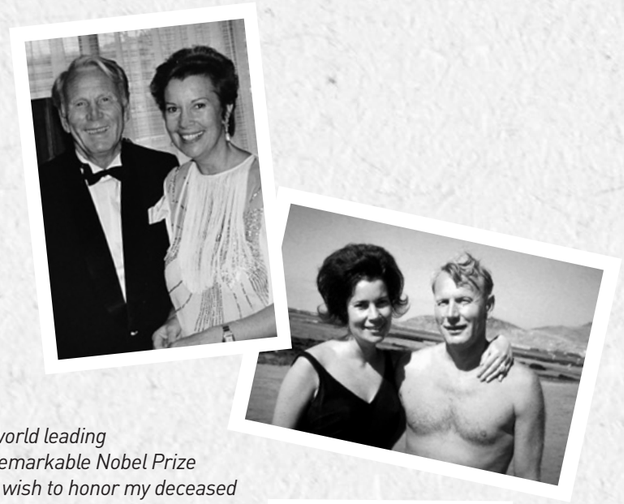
FINDING THE KEY NEURAL CODING PRINCIPLES UNDERLYING HIGHER MENTAL FUNCTIONS
By studying the normal developing brain, we seek to understand how neural networks enable us to map and navigate geographic and memory landscapes, and to assemble our rich inventory of knowledge. Data on the neural mechanisms and processes that generate higher-level cognitive functions in the normal brain, may in the future enable new and innovative treatments for a range of neurological and psychiatric diseases.



CLOSING THE GAPS IN OUR KNOWLEDGE – AND ESTABLISHING NEW CONNECTIONS
By translating promising animal research to humans, we aim to secure a solid foundation of knowledge on Alzheimer's disease in the human brain, thereby improving the success rate of future diagnostic tools and treatments. By investigating the grid cell system beyond navigation in physical landscapes, we seek to find out whether its coding principles also support conceptual knowledge acquisition and mapping of abstract structures.

UNDERSTANDING THE CONDITIONS BY WHICH NEURODEGENERATIVE DISEASES CAUSE HIGHER MENTAL FUNCTIONS TO BREAK DOWN
The grid cell, the main protagonist in the brain´s GPS, is among the very first to be affected by Alzheimer's disease. Translating research from the healthy to the diseased brain, enables us to apply knowledge from basic research when investigating why the systems of memory and navigation break down in Alzheimer's disease, and to develop treatments and better diagnostic tools for early detection of neurodegenerative diseases.

In Mrs. Braathen's words



- With this grant, I want to recognize and encourage the world leading neuroscience research in Trondheim which is led by the remarkable Nobel Prize Winners May-Britt and Edvard Moser. At the same time, I wish to honor my deceased husband, Egil Braathen, who had a lot to be grateful to St. Olav's Hospital for. The research led by May-Britt and Edvard Moser has great importance for a world in need of increased knowledge about how the brain works, in order to prevent and cure disease and illness related to the brain. I believe that this unique combination of research and clinical excellence has the prerequisites to find the answers to the Alzheimer mystery.

Pauline Braathen, on the donation realizing the new Egil and Pauline Braathen and Fred Kavli Centre for Cortical Microcircuits at the Kavli Institute for Systems Neuroscience.

Egil Braathen´s nieces Anita Lien and Mona Arnesen, and his nephew Erik Ruud.

- His eyes were empty, but his words "Are you my wife?" filled mine with tears.

Pauline Braathen, on slowly losing her beloved husband to Alzheimer's disease.

- I know there are millions who suffer with Alzheimer's and many millions more who suffer in another way caring for their loved ones, but just at the time I felt uniquely tortured and truly alone.

Mrs. Braathen lost her husband of 46 years in 2009, after a prolonged period of advanced Alzheimer's disease.


NYHETER

Pengeinnsamling til Moser

Gaven fra en britisk millionderenke gjør Mosers drømmer til virkelighet.

Britisk enke gir 50 millioner til Mosers forskning

Forskningsgave

Pauline Braathen

SELGE BOLIG?

– We are morally obliged to help solve one of the greatest challenges for global health of our time.

Edvard Moser

Pauline Braathen is a philanthropist in the great Anglo-American tradition. Like Bill Gates and Warren Buffet, she has decided that her fortune will channel back to the community providing lasting value for those coming after her.

Value, not in terms of money, but in terms of securing stable, long term funding for basic research that is devoted to solving the mysteries of the brain and alleviating some of the most heartbreaking sufferings that afflict humankind.

Mrs. Braathen has since long been wanting to express her gratitude to the medical team at the hospital in Trondheim, who once saved her husband, Egil Braathen's life by performing world class pioneering surgery. As she later learned about the research done at the Institute run by May-Britt and Edvard Moser, and about the gift trusted to them by the Kavli Foundation, and further about the Nobel Prize in Physiology or Medicine 2014 awarded to them for their groundbreaking discoveries – things had come full circle for Pauline. Within the same innovative research environment that once had come to her husband's rescue all those years ago, a new world class research community had developed, holding the potential for saving millions of people worldwide.

Pauline Braathen is donating most of her remaining assets in the effort to realize a new center for brain research at the Kavli Institute that will cooperate with St. Olav's Hospital in Trondheim. She is joined by three of her late husband's nephew and nieces Anita Lien, Mona Arnesen and Erik Ruud in making this substantial donation, and thus provide one of the largest philanthropic contributions in the history of Trøndelag County.

Harald Ellefsen

Attorney of Law

Stig Slørdahl

CEO at the Central Norway Regional Health Authority

The hippocampus of KISN

Excellent support enables excellent science – this is the mantra of the Support group and the Technical staff.

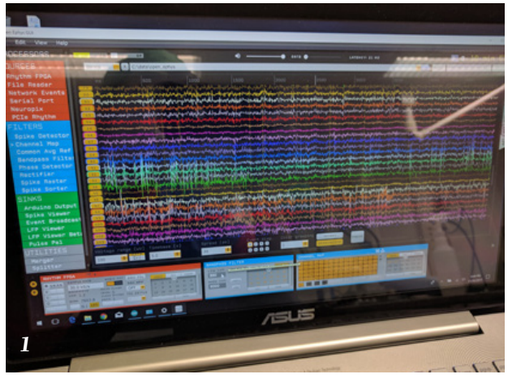
A staff of highly dedicated technicians, administrators and specialists are providing their knacks to the research groups across the centre. Diversified in skill and training, the individuals of these groups attend to the animals' welfare, assist scientists in designing tools and practical solutions for the novel experiments they envision, they help organize conferences and events, nurture local and international relations, keep track of economical and organizational matters as well as digital solutions.

These are the workers the Director fondly refers to as the hippocampus of the Centre, archiving information from short-term memory, retrieving knowledge from long-term memory, establishing long-term potentiation of preparedness based on recent activities, and in general providing cues used for navigation and speed by the leaders.

First row from left: Lisbeth Aune, Christina Schrick, Eirin Hårstad, Waldemar Zareba, Qiangwei Zhang, Alice Burøy, Nenitha Charlotte Dagslott. Second row from left: Dina Hestnes, Klaus Jenssen,, Siv Eggen, Endre Kråkvik, Ann Mari Amundsgård, Paulo Girão, Mussie Debesai. Third Row from left: Grethe Mari Olsen, Haagen Waade, Kyrre Haugen, Anne Lise Stamnes, Hanne Tegnander Soligard, Vadim Frolov. Forth row from left: Hanne Mali Møllergård, Bruno Monterotti, Grethe Jakobsen, Rita Elmkvist Nilsen, Lisbeth Normann Mitlid, Ingvild Ulsaker Kruge. Also in the group but not present when the photo was taken: Solfrid Nordtug, Bente Skei, Rannveig Tellemand Storeng, Anne Merethe Winther, Merethe Andresen, Maria Gangstø.

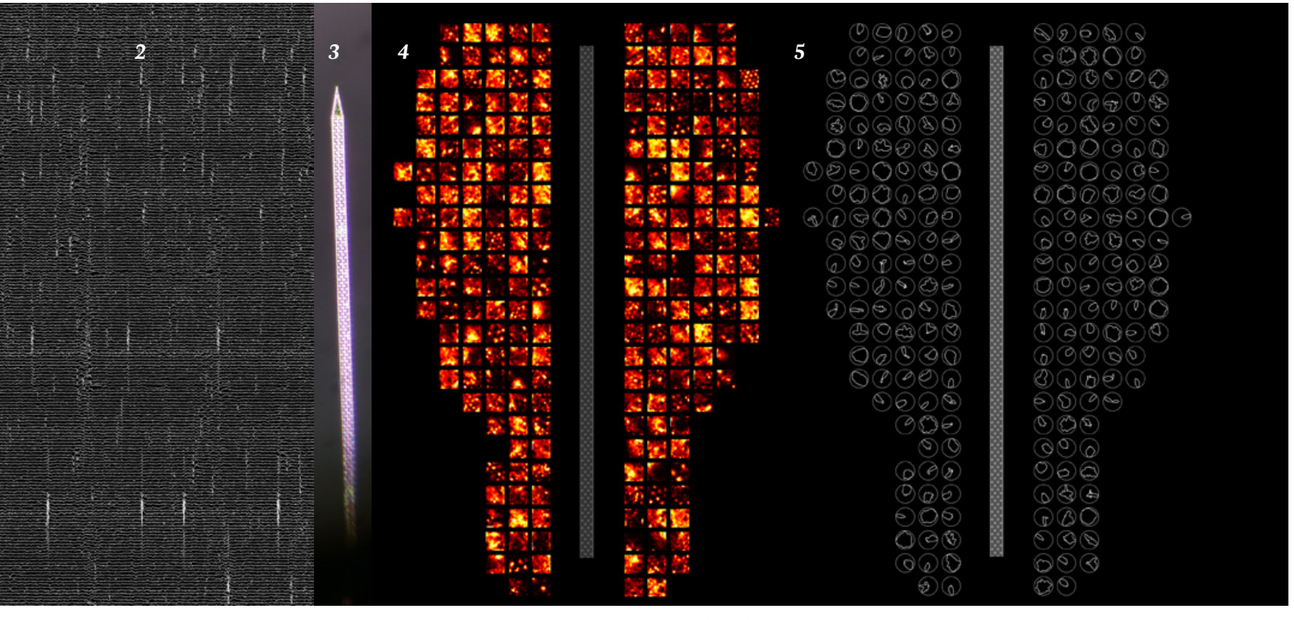
Promising research

Kavli Institute for Systems Neuroscience is introducing new and emerging technologies for registering activity in thousands of cells simultaneously in freely navigating rodents.
This involves a new microscope technology as well as silicon probes with up to 1000 channels for measuring electrical signals. These technologies will revolutionize neural population analysis in the cortex.



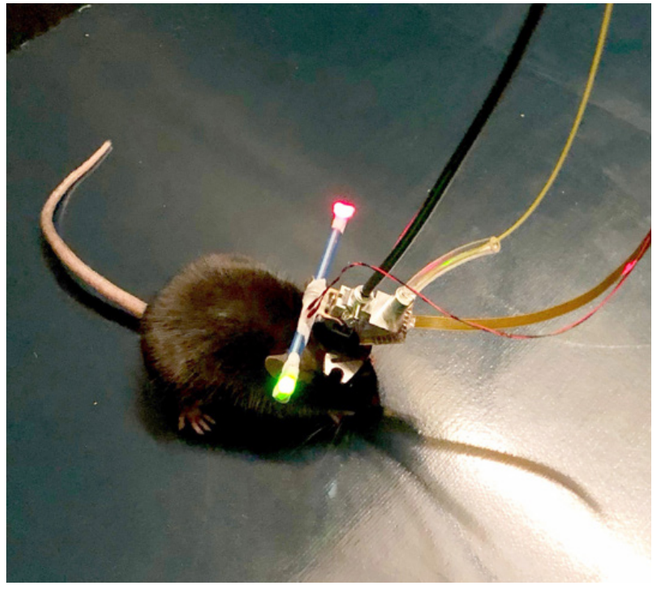
Picture 1: November 30 2017, around 7 pm: First signals from one of our very first silicon probe tests. 25 channels are recording from the area of the hippocampus called CA1. We can see spiking neural activity from several of the channels. The screen shot covers 5 seconds of activity. Image generated by Ingvild Kruge, Moser Group.

Picture 2: 200 ms of voltage traces from 200 channels recording neural activity in the medial entorhinal cortex with 50 ms time duration. Image generated by Richard Gardner, Moser Group.

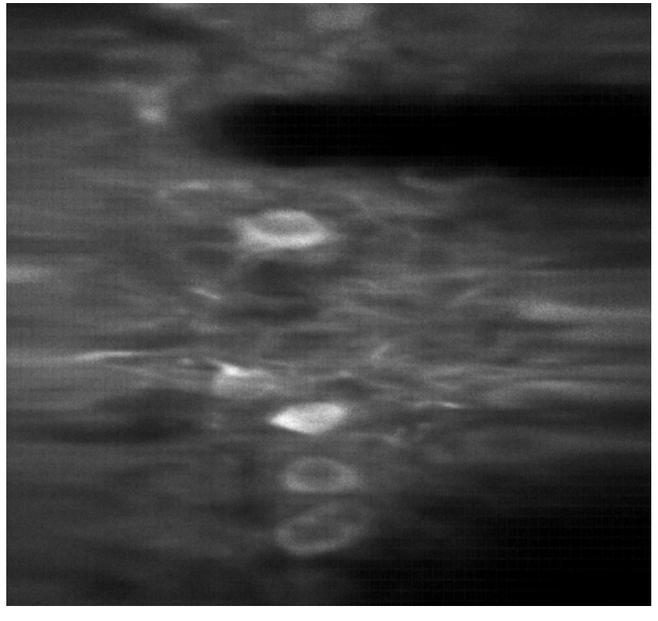


Picture 3: A close-up of the Neuropixels probe shank. Image captured with mobile phone camera through the microscope. Image generated by Richard Gardner, Moser Group.
Picture 4: Firing rate maps of 239 cells in the medial entorhinal cortex, recorded simultaneously on one portion of the Neuropixels probe shank. The rate maps are positioned close to the locations they were recorded on the probe (shown in center). Image generated by Richard Gardner, Moser Group.
Picture 5: Same as left, but this plot shows head-direction tuning curves. Image generated by Richard Gardner, Moser Group.

Two sides of the very first freely-moving two-photon miniscope experiment at the institute performed 19. March 2018.



Mouse Flora running around with the first miniaturized two-photon microscope and two tracking LEDs (green and red). Fibers for the excitation and detection of the imaged signal emanate from the implant, as well as wires for LEDs and the miniaturized microscope scanner mounted on the skull. The microscope assembly is removable and the mice can be imaged over several sessions during naturalistic behaviour. Image generated by Horst Obenhaus, Moser Group.



Neurons in medial entorhinal cortex (MEC) of the mouse brain. Average projection of firing neurons labeled with GCaMP6s, a genetically encoded calcium indicator, during the first freely moving experiment with a miniaturized two-photon microscope. Cell bodies and single dendrites are clearly discernible from the background and enable the analysis of neuronal activity in anatomically defined cell populations and cellular compartments in the mouse brain. Image generated by Horst Obenhaus, Moser Group.

Researcher Training

MASTER OF SCIENCE IN NEUROSCIENCE
The Master of Science (MSc) in Neuroscience at NTNU provides an in-depth study of brain structure and function, reaching from the molecular to systems level. A central aim for students is to understand how neural systems may contribute to sensory experiences, thoughts, emotions and behaviour, and learn to adopt experimental methods to gain new knowledge in the field.

The MSc in Neuroscience is a two-year, full-time programme. The teaching includes lectures, laboratory work/demonstrations and supervised project work. The language of instruction is English. Both Norwegian and international students are welcome to apply for a seat.

NEUROSCIENCE PHD PROGRAMME AT KISN
The objective of the Neuroscience PhD Programme is to provide theoretical and methodological training in neuroscience research and to contribute to increased understanding about basic biological principles for neural structure and activity and their importance for movement, sensory and autonomic functions, emotions, behaviour and cognitive processes in animals and human beings. Studies of normal function as well as elucidation of mechanisms for neurological and psychiatric illnesses are relevant. Through own research the students will learn to formulate and solve scientific questions and at the same time they will acquire basic skills and methods in parts of neuroscience.

PhD-candidates receive supervision from their principal investigator as well as from a relevant co-supervisor, either within or externally of the institute. They present at internal journal clubs, data clubs and are encouraged to submit abstract and present poster at national and international conferences. Some PhD students co-supervise MSc students.

LIST OF PHD DEFENSES CARRIED OUT AT KISN IN 2017:
2017: There were three dissertations in 2017.
Grethe Mari Olsen (f), Asgeir Kobro-Flatmoen (m), Ingrid Åmellem (f).

There is 40 active PhD-candidates at KISN per 31.01.2018.

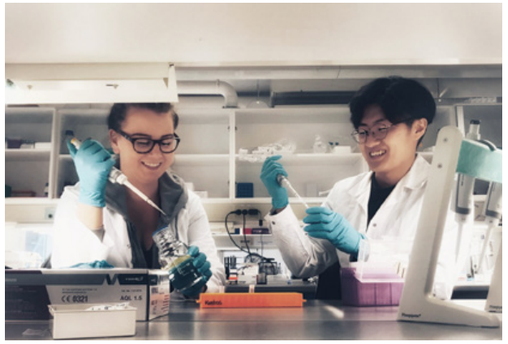
NORWEGIAN RESEARCH SCHOOL IN NEUROSCIENCE
The Norwegian Research School in Neuroscience (NRSN) is an initiative aimed to bring together the research training expertise in the field of neuroscience from NTNU, University of Oslo, University of Bergen, the Norwegian University of Life Sciences, and University of Tromsø.

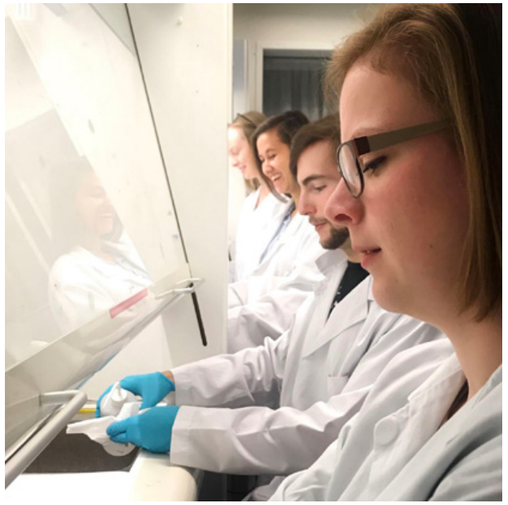
By combining the specific expertise of the participating institutions, the NRSN aims to facilitate the PhD research training that will enable the next generation of Norwegian-trained neuroscientists to face the great challenges and opportunities in the field.

The NRSN is funded by the Norwegian Research Council, with an annual budget of around 3 Mill NOK. The NRSN board is composed of representatives from all partner institutions. The daily management is hosted by the Faculty of Medicine, NTNU, and the scientific director is a PI at KISN.

The NRSN organize a weeklong summer school each year at various locations in Norway. The summer school in 2017 was hosted at KISN and was considered successful with positive feedback from the participants.

THE MEDICAL STUDENT'S RESEARCH PROGRAMME (MSRP)
The Medical Student's Research Programme (MSRP) is a national research education and grant scheme for medical students who wish to carry out research in parallel with their studies. The Medical Student's Research Programme is offered to a group of the medical students (10%), who are interested in medical research, and willing to do research besides their studies.





The students at the MSRP follow the ordinary medical study. In addition to this, they achieve an organized research education and get to perform their own research activity, which might be the beginning of a PhD.

The students are affiliated at the MSRP after second or third year of their medical study. To be a student at the MSRP involves that their regulated medical study syllabus will be prolonged by one year, from 6 to 7 years. The students at the MSRP are affiliated at the research programme in 4,5 years, In two semesters and two summers they are full time resarchers, the rest of the time period they are part time resarchers. Fulfilled MSRP will give a total of 120 ECTS, in addition to the ordinary study. Many of these students will subsequently enter a fast-track PhD program which takes an additional 2 years. At KISN we have had 1 MSRP students defending their PhD theses.

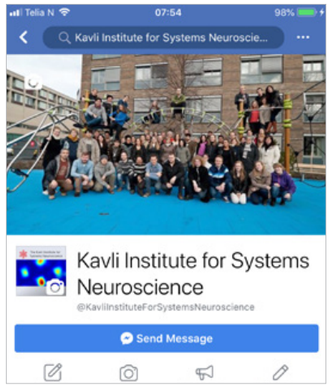
POST-DOCTORAL
Post-doctoral researchers are employed at KISN based on either writing proposal for part-projects relevant of already funded research projects, or by applying for funding themselves within their research group. Access to infrastructure such as the national infrastructure scheme NORBRAIN (equipment), administrative and technical help is provided. Our post-docs are fully integrated with the institute and they receive supervision from their principal investigator as well as from a relevant co-supervisor, either within or externally of the institute. They present at internal journal clubs, data clubs and are encouraged to submit abstract and present poster at international conferences. Abroad stay and collaboration is highly encouraged and supported. Some will co-supervise PhD students or MSc students as part of their responsibilities.

PRINCIPAL INVESTIGATOR
There are currently seven research groups at KISN with in total eight principal investigators. It is a requirement that new principal investigators have at least one mentor in the start-phase to give advice and support in the next step of their career. Young PIs now receive two mentors, one internal, familiar with the Norwegian University system, and one external.

ALUMNI
Our alumni of trained researchers who has spent time and effort at KISN tells us we are succeeding in our ambition of being a nurturing and developing nest for young minds to grow and expand their work-environment to stay international. KISN recruits independently of nationality or origin. Since 2013 we have had more than 30 different nationalities represented among employee staff. For a given period, the international researcher is located in Trondheim, side by side with other internationals, learning, developing and exploring, before returning home, continuing their research careers as PhDs, post-doctors, or researchers, or even forming their own research group and becoming principal investigators. Numerous PhD students and postdocs of KISN have achieved faculty and group-leader positions at internationally well-recognized universities and institutes such as Stanford University, University of California in San Diego, University of California at Irvine, University of Texas at Austin, the Max Planck for Brain Research in Frankfurt, and the University of Oslo, among others.

2017 at a Glance

January



SoMe: Kavli Institute for Systems Neuroscience is on Facebook since August 2007.

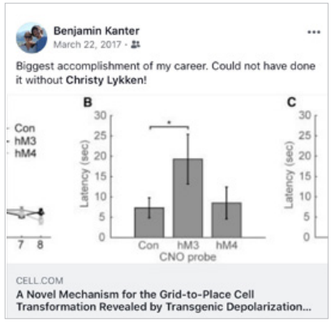
May-Britt Moser, Katja Brose, Gyorgy Buzsaki and Pedro Valdes Sosa discussed neuroscience on the Cuban public television talk show Mesa Redonda Internacional.

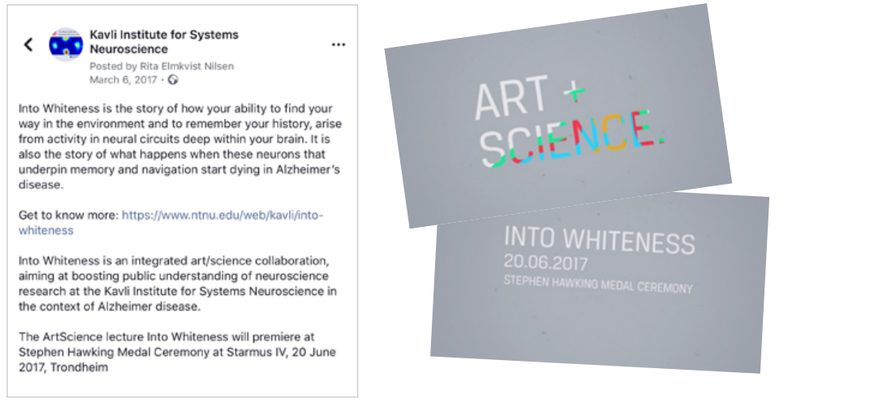
May-Britt Moser and her team performed the Art-Science collaboration 'Lost Memory' at the Cuban Neuroscience Center, as part of the CNEURO seminar open to the public. The Norwegian scientists and artists joined forces with the local musical group Camerata Romeu for a full orchestral experience on stage. The public seminar was followed by a two-day exclusive Kavli Salon neuroscience meeting at Hotel Nacional, Havana.

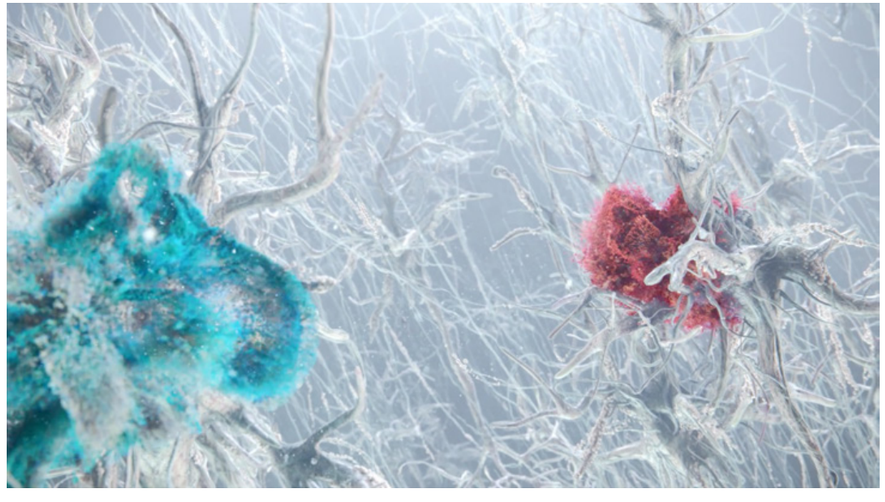
February

March

Providing science advice for policy and decision-making: Edvard Moser was invited as Keynote for the Norwegian Government Summit, where he talked about the importance of basic research to combat brain diseases. Photo: Edvard Moser with Prime Minister of Norway, Erna Solberg.

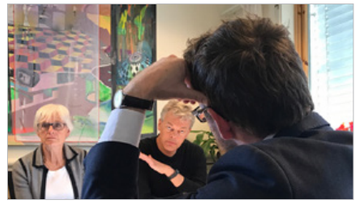


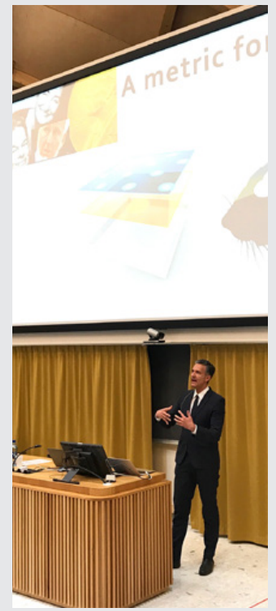




May

Minister of Education Torbjørn Røe Isaksen and State Secretary Bjørn Haugstad visited the Kavli Institute to discuss long-term funding schemes for top level science.

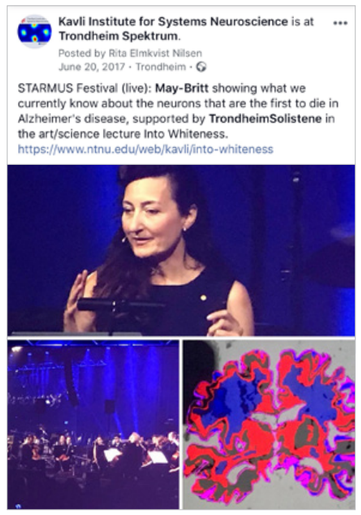


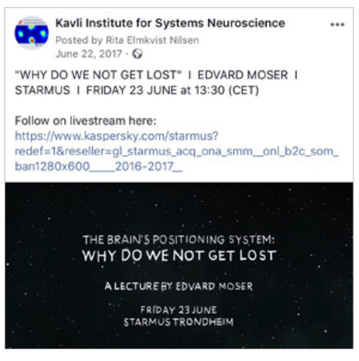


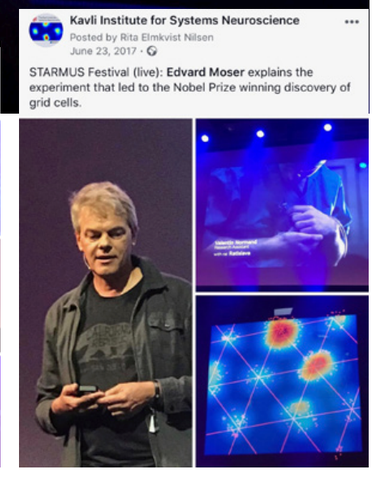
The Foreign Ambassadors in Norway and the Ministry of Foreign Affairs visited Kavli Institute. They were greeted with a rich program of science, art and talks by Pro-Rector Kari Melby, Mayor of Trondheim Rita Ottervik, Dean Björn Gustafsson, Finance Expert Rune Haglund at Trondheim Foundation for Scientific Research, Trondheim-Solistene, and Professors May-Britt Moser, Edvard Moser and Christian Doeller (photo).

June

SoMe: Kavli Institute for Systems Neuroscience is now on LinkedIn.







The festival gathered 11 Nobel Prize Laureates for one of its four panel debates.

The local and regional co-organizers of the Starmus festival. From left: Tore O. Sandvik, David Eicher, Rita Ottervik, May-Britt Moser, Garik Israelian, Gunnar Bovim, Edvard Moser, Robert Williams.

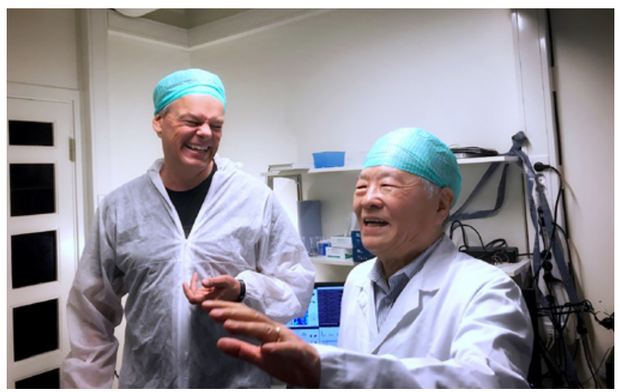
KISN + STARMUS = OUTREACH

Edvard Moser and May-Britt Moser were, together with festival leader Garik Israelian, instrumental in bringing the fourth international Starmus festival for Science and Art to Trondheim. Moser and Moser were actively involved in the organized effort to communicate science to a diverse set of participants, ranging from non-scientists; school children; government representatives and policy makers; science communicators; artists; researchers and scholars. The festival gathered 11 Nobel Laureates, 10 astronauts, three of whom have walked on the moon, and a varied selection of star communicators from the arts and sciences. The festival had an extensive program for the entire population of Trondheim. 45.000 people participated in various science communication events during the six days of the festival, and many more followed the online live-stream and the national broadcast of the lectures.

The Kavli Institute embraces values of inclusivity and public engagement with science. We believe that the public's knowledge and support is a precondition for sustaining a participatory democracy. And that insight into scientific processes lays the foundation for public faith in scientific facts. We also support the notion that participatory engagement generates a critical capacity within the public for assessing the reliability of various types of information, and thereby creating robust societies. We understand our own efforts in this field as part of our obligations to the society that to a great extent fund the research at our Institute.

The impacts of a science festival of this magnitude should be examined as a cultural phenomenon. Shaping not only our understanding of the world, but also how we as individuals and as a society reflexively come to understand ourselves: As someone who belongs in and actively engages with science and policy debates that concern the life we want to live and the society that we want to be.

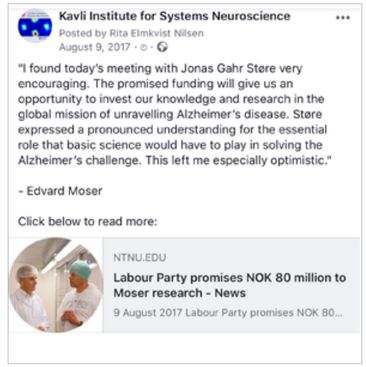
European Commissioner of Research, Science and Innovation, Carlos Moedas visited our lab and expressed his enthusiasm for our commitment to enrichment and animal welfare.



Nobel Prize Laureate Susumu Tonegawa and wife Mayumi Tonegawa visiting the lab, discussing with researchers David Rowland, Horst Obenhaus and Edvard Moser.

August

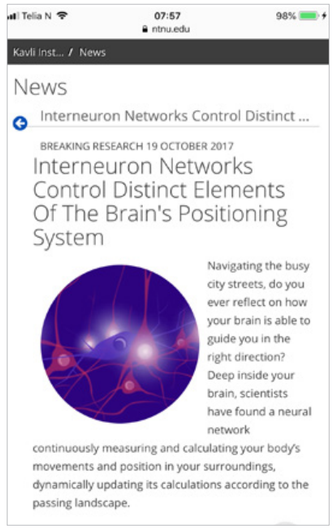
Rannveig Tellemand Storeng starts in the newly established position as Managing Director for the Kavli Institute for Systems Neuroscience.



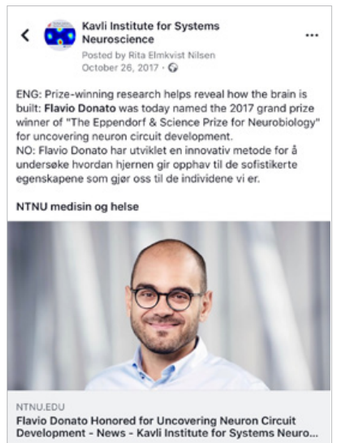
September

SoMe: Kavli Institute for Systems Neuroscience is on Flickr

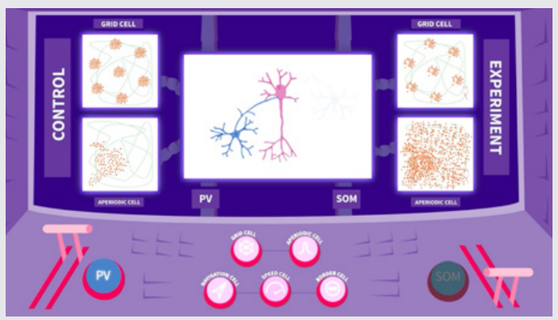
October



SoMe: Kavli Institute for Systems Neuroscience now has a News blog.



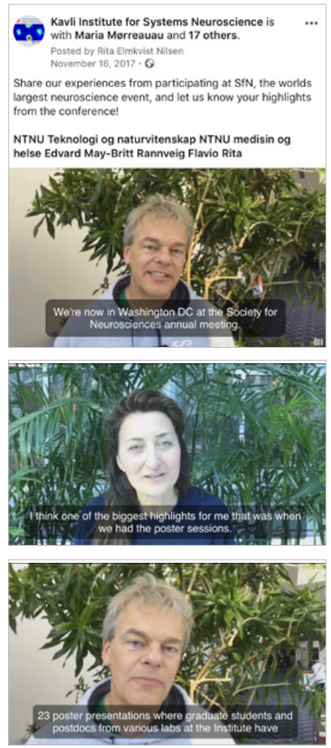
Reaching out to various groups of readers: In May and June, we made a video animation explaining some guiding insights to how the brain deals with space and memory. The animation was aimed at young people and the general audience. In October, researchers Miao, Cao, Moser and Moser published their exciting discoveries about the inner workings of networks that underpin our ability to navigate. For a general reader however, access to the story is conditioned by multiple layers of abstract knowledge. In an effort to lower the threshold for engagement with this paper in the science community, and at the same time making this research available for a slightly broader group of interested readers, we put together a 4-minute long animation video summing up the key points of the paper. The video was published in the online journal Cell together with the article. In addition to the video, we inaugurated our news blog with a post that went one step further in explaining the paper and the video in ever more general terms.

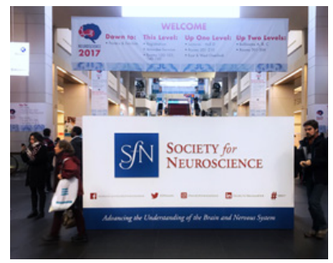


November

SoMe: Kavli Institute for Systems Neuroscience is now on Twitter

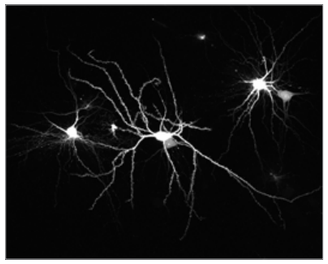
Emilie Skytøen with her mentors and her opponent Bolek Srebro, after fulfilling the Medical Student's Research Programme.

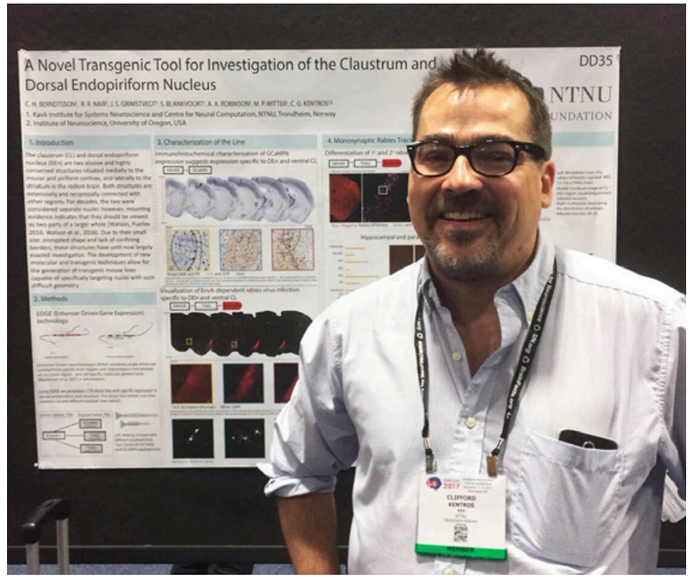




Kavli Neuroscience
@KISNeuro

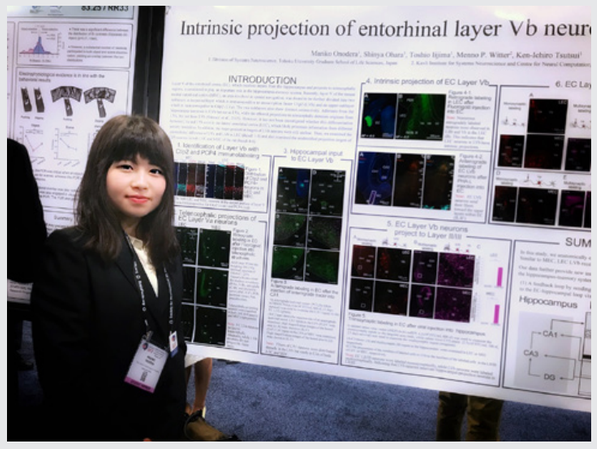
We have developed a novel transgenic tool that allows us to investigate the claustrum, of which little is yet known but has been suggested to be associated with consciousness. Come by our #SfN17 poster 775.10/DD35 at 1-5 pm today and have a chat with our researchers.





Kavli Neuroscience
@KISNeuro

Time represented in the LEC: The lateral entorhinal cortex provides the hippocampus with a timestamped representation of experience. Come by #SfN17 poster 84.21/SS20 at 1-5 pm today to learn more.



Kavli Neuroscience
@KISNeuro

First report on Object Vector cells in the MEC. Displaying firing fields at fixed distances and directions relative to object location. The response features are immediate, and reproducible across environments and object identities. Visit poster 84.17/SS16 at 1-5 pm today #SfN17

Kavli Institute for Systems Neuroscience
Posted by Rita Elmkvist Nilsen
November 9, 2017 ·

We are proud to share the good news that Professor **Emre Yaksi**, Kavli Institute for Systems Neuroscience, is appointed NCMM Associate Investigator.

Centre for Molecular Medicine Norway (NCMM) is an international biomedical research centre, with the overall objective of translating basic medical research into clinical practice. NCMM is a part of UiO's interdiciplinary focus on life sciences.

Following an open call for talented researchers who were interested in collaborating with NCMM, the successful candidates have been appointed after careful evaluation by a Selection Committee. The final candidates were chosen on the basis of their scientific excellence, translational merit and/or the ability to build networks that bridge from basic science to clinical medicine, compatibility with the NCMM mission and added value they could bring to NCMM. The standard and quality of candidates was very competitive, with excellent applications.

December

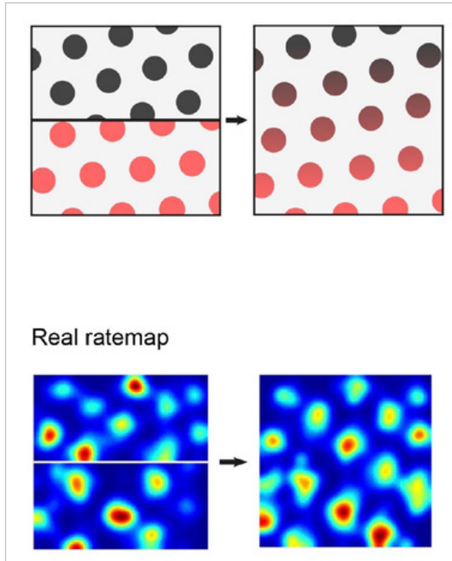
Our new paper in #PLOSBiology: Saccades are phase-locked to alpha oscillations in the occipital and medial temporal lobe during successful memory encoding. dx.plos.org/10.1371/journa... With @neuosc, @doellerlab, E. Hartl and S. Noachtar.

12/21/17, 20:45

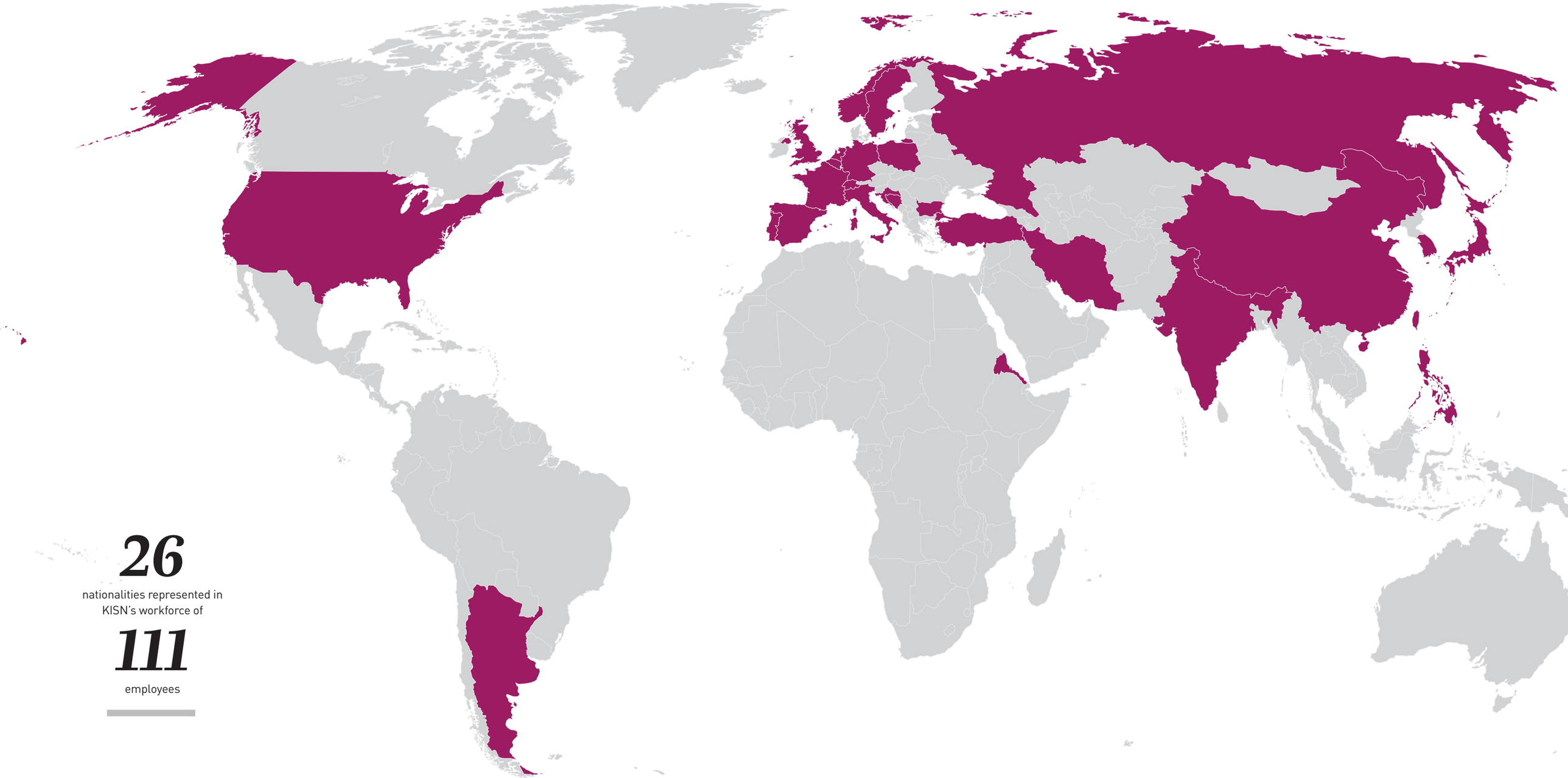
Santa and his little helper made it to the @KISNeuro Christmas party! Thanks to all secret santas!

Kavli Neuroscience
@KISNeuro

What happens in the brain when navigating between familiar environments? @TanjaWernle et al. at @KISNeuro @sissaschool reveal how fragments of local grid maps are merged together into one coherent map by local readjustment of grid fields along the seam: nature.com/articles/s4159...



Facts



26

nationalities represented in
KISN's workforce of

111

employees

2017 Highlights

HIGH IMPACT PUBLICATIONS

Donato, Flavio; Jacobsen, R. Irene; Moser, May-Britt; Moser, Edvard Ingjald. (2017) Stellate cells drive maturation of the entorhinal-hippocampal circuit. **Science**, vol. 355 (6330).

Kanter, Benjamin Richard; Lykken, Christine Marie; Avesar, Daniel; Weible, Aldis; Dickinson, Jasmine; Dunn, Benjamin Adric; Zuiderveen Borgesius, Cornelis Herman; Roudi, Yasser; Kentros, Clifford. (2017) A Novel Mechanism for the Grid-to-Place Cell Transformation Revealed by Transgenic Depolarization of Medial Entorhinal Cortex Layer II. **Neuron**, vol. 93 (6).

Kaplan, Raphael; Schuck, Nicolas W.; Doeller, Christian F. (2017) The Role of Mental Maps in Decision-Making. **Trends in Neurosciences**.

Miao, Chenglin; Cao, Qichen; Moser, May-Britt; Moser, Edvard Ingjald. (2017) Parvalbumin and Somatostatin Interneurons Control Different Space-Coding Networks in the Medial Entorhinal Cortex. **Cell**, vol. 171 (3).

Moser, Edvard Ingjald; Moser, May-Britt; McNaughton, Bruce. (2017) Spatial Representation in the Hippocampal Formation: A History. **Nature Neuroscience**, vol. 20 (11).

Staudigl, Tobias; Hartl, Elisabeth; Noachtar, Soheyl; Doeller, Christian F.; Jensen, Ole (2017) Saccades are phase-locked to alpha oscillations in the occipital and medial temporal lobe during successful medial temporal lobe during successful memory encoding. **PLoS Biology**.

Wernle, Tanja; Waaga, Torgeir; Mørreaunet, Maria; Treves, Alessandro; Moser, May-Britt; Moser, Edvard Ingjald. (2018) Integration of grid maps in merged environments. **Nature Neuroscience**.

LARGE INTERNATIONAL PROJECTS AND CONFERENCES ORGANIZED

EDVARD MOSER
Francis Crick symposium in neuroscience, China, 8-12 May (co-org)
2nd Nordic Neuroscience meeting, Stockhom 7-9 June
Starmus Science Festival IV, Trondheim, 18-23 June (co-org)
Ascona Cicruit: 1– 6 October (co-org)

MAY-BRITT MOSER
Kavli Salon Neuroscience, Havana, 19-21 February (co-org)
Starmus Science Festival IV, Trondheim, 18-23 June (co-org)

JONATHAN WHITLOCK
Scientific Director for the NRSN summer school, Trondheim, 13-19 August

MENNO WITTER
The CAJAL ADVANCED TRANING COURSE Interacting with Neural Circuit, Lisbon, 2-22 July

EMRE YAKSI
FENS Kavli Network of Excellence, Winter Symposium, Vienna, 3-5 December

PRIZES, HONOURS AND AWARDS

MAY-BRITT AND EDVARD MOSER
Honorary Doctorate: University of Bergen, Norway, 5 May
Lars Onsager Lecture 2017, Norwegian University of Science and Technology, Norway, 25 January

EDVARD MOSER
Annual Albert Einstein Lecture, Israel Academy of Sciences and Humanities, Jerusalem, 14 March
Advisory Council member RIKEN BSI SAS, 29-30 September

MENNO WITTER
Visiting Science Scolarship award, KNDI John Hopkins, Baltimore, 2017-2019

FLAVIO DONATO
Eppendorf & Science Prize for Neurobiology, Washington DC, 25 October

Annual accounts

INCOME	
Norwegian Research Council: Centre of Excellence	21 500 000
Norwegian Research Council: Other	20 354 000
International Funding	19 647 700
Other Public/Private	8 014 000
Norwegian University of Science and Technology	68 177 300
TOTAL INCOME	137 693 000

EXPENSES	
Payroll and indirect expenses	111 439 963
Equipment	2 201 009
Other operating expenses	24 052 028
TOTAL EXPENSES	**137 693 000**

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