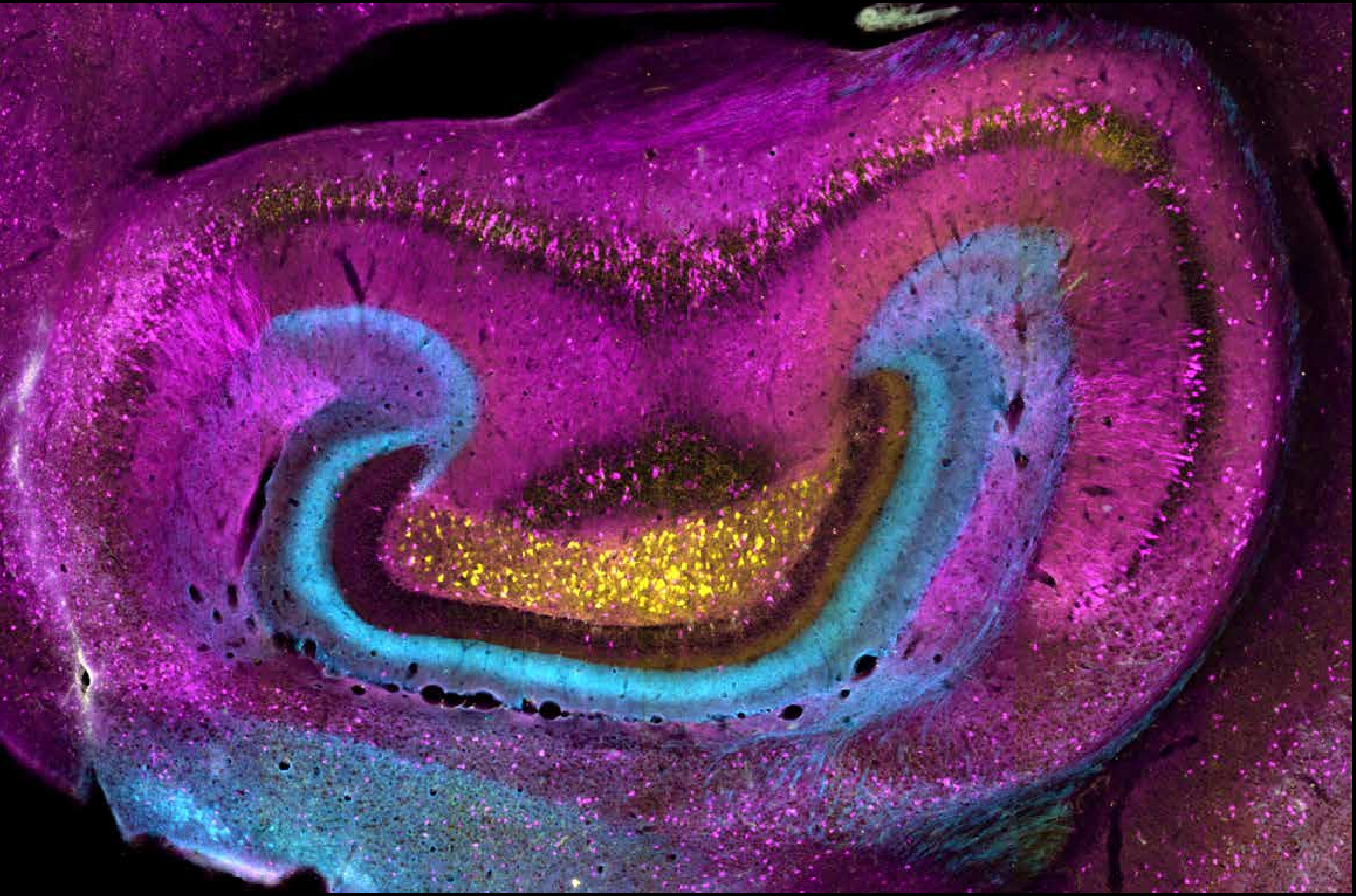
Kavli Institute
for Systems Neuroscience

2024 AT A GLANCE

Graphic summary of the annual report

Norwegian Centre of Excellence · erc European Research Council · Trond Mohn Foundation · Stiftelsen Kristian Gerhard Jebsen · The Kavli Foundation · NTNU Norwegian University of Science and Technology



This is a histology image. It is a fixed brain slice showing the hippocampus of a mouse in sagittal orientation. Recorded with a fluorescence microscope (AxioScan widefield microscope). The colours don't resemble the actual colours of the proteins or dyes used. In cyan we see the axons of stellate cells from the MEC terminating in the hippocampus. These cells are transfected with GCaMP, a green calcium indicator. In magenta we see parvalbumin interneurons that are genetically labelled with td-Tomato, a red fluorescent protein. In yellow we see cells in the hilus of dentate gyrus that are tagged with colera-toxin B which induced a red dye called Alexa.
Image credit: Martin Pofahl/Kavli Institute



Dear reader

With the Kavli Institute for Systems Neuroscience's (KISN) third consecutive Centre of Excellence award, each spanning a decade, the Institute is poised to advance the next generation of research into the computational mechanisms of neural circuits. At the heart of this endeavour is the Centre for Algorithms in the Cortex (CAC), dedicated to uncovering the fundamental computational rules that drive high-level brain functions, including sensory perception, motor planning, navigation, memory, and time perception.

Our approach spans multiple species, fish, rodents, and humans, and different cortical regions, to investigate whether common brain algorithms are reused across functions and how these computational principles emerge during development. With cutting-edge tools that allow both large-scale neural recording and precise perturbation of activity in thousands of interacting neurons, CAC seeks to reveal how higher cognitive functions arise from collective neural dynamics.

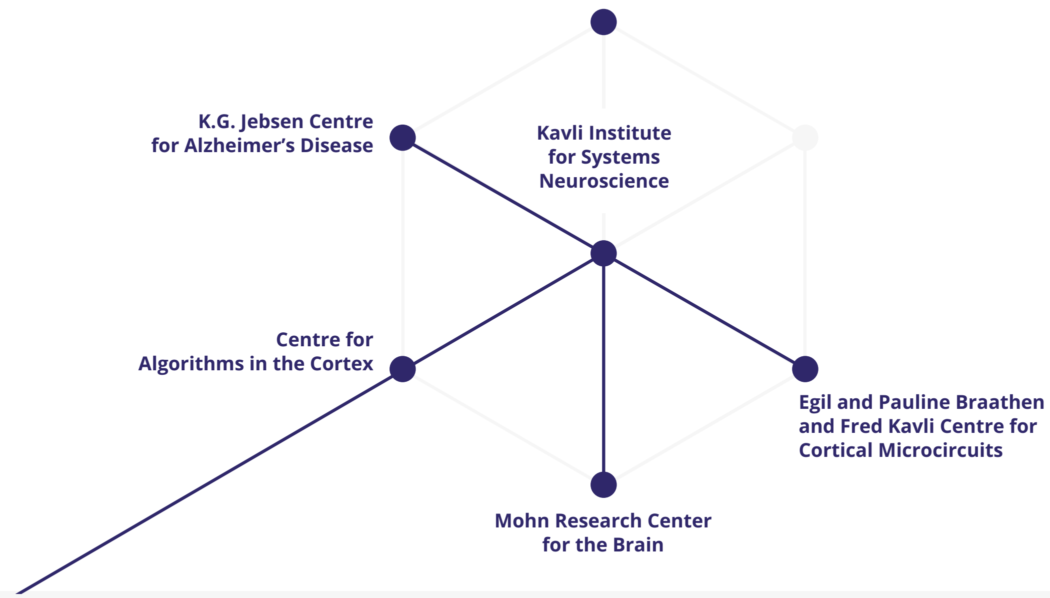
A key strength of the Centre lies in its synergy between theory development and experimental testing - a necessary interplay for deciphering computational principles that cannot be inferred from observations alone. Our research is organized into four interdisciplinary work packages, tackled by ten research groups led by experts from diverse fields, including psychology, physics, molecular biology, and more.

We invite you to explore this graphic summary of 2024, showcasing key facts and figures from our research. For early access to the latest breakthroughs from the Kavli Institute for Systems Neuroscience, simply scan the QR code on the back cover of this folder.

Enjoy the discoveries ahead!

May-Britt Moser, Edvard Moser, Bjarne Foss
Directors of the Kavli Institute for Systems Neuroscience

Organisational chart 2024



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Scientific Director

MAY-BRITT MOSER
Scientific Director

BJARNE FOSS
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Institute, centres and infrastructure

> *Understanding the brain is one of the greatest challenges to science, with brain disorders affecting one in three Europeans during their lifetime.*

KAVLI INSTITUTE FOR SYSTEMS NEUROSCIENCE (KISN)

The Kavli Institute for Systems Neuroscience is a leading research environment in Trondheim. The lab that preceded the institute was founded by Nobel Laureates May-Britt Moser and Edvard Moser in 1996 to investigate the emergence of higher brain functions.

Today, the Kavli Institute is an interdisciplinary village of experts with the common desire to understand how complex information is encoded in high-level neural networks and how complex behaviours arise from these codes and systems.

The institute staff is organized in ten research groups and several support groups such as Animal Tech, Technical Group, Kavli Communication, and an Administrative team.

Centres
The neuroscience research institute, led by Edvard Moser, May-Britt Moser and Bjarne Foss, now comprises four research centres:

- Centre for Algorithms in the Cortex (CAC)
- Egil and Pauline Braathen and Fred Kavli Centre for Cortical Microcircuits (BKC)
- K.G. Jebsen Centre for Alzheimer's Disease (JCA)
- Mohn Research Center for the Brain (MCB)

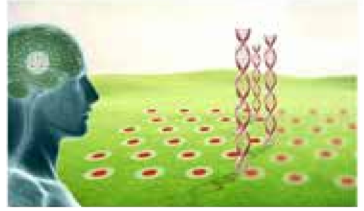
Education
The department is responsible for an international master's degree programme in neuroscience. It has joint responsibility for the PhD programme in medicine and health sciences at NTNU. The Norwegian Research School in Neuroscience (NRSN) is organised and run by the institute with support and participation of the major Norwegian universities.

Infrastructure
The institute is the national host of NORBRAIN, a large-scale infrastructure for neuroscience technology, with facilities located at the University of Oslo (UiO), the University of Bergen (UiB), and the Norwegian University of Science and Technology (NTNU) in Trondheim. The institute is also host to the only Viral Vector Core in Norway, supplying labs across the world with state-of-the-art viral research tools.

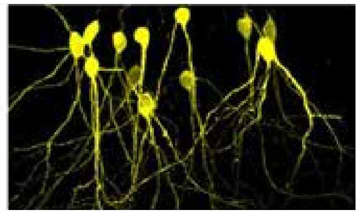
History
The Kavli Institute for Systems Neuroscience consists of a Centre of Excellence (CoE) awarded by the Research Council of Norway since 2002, a Kavli Foundation Institute since 2007, a Braathen-Kavli Centre since 2015, a department at the Faculty of Medicine and Health Sciences at Norwegian University of Science and Technology (NTNU) since 2017, a Foundation Stiftelsen Kristian Gerhard Jebsen Centre since 2020, and a Trond Mohn Foundation Research Centre since 2021.

Centre for Algorithms in the Cortex

K.G. Jebsen Centre for Alzheimer's Disease



Braathen and Kavli Centre for Cortical Microcircuits



Mohn Research Center for the Brain

NORBRAIN

VIRAL VECTOR CORE

Norwegian Research School in Neuroscience

TFSR
The Research Fund of the Kavli Institute for Systems Neuroscience

For Twenty Years, Grid Cells Kept a Secret

Rather than simply tracking an animal's real-time location, grid cells coordinate to perform rapid, rhythmic sweeps into the space ahead of the animal.

A breakthrough discovery at the Kavli Institute in Norway has uncovered a previously unknown function of grid cells, the specialized neurons that help the brain map space.

Discovered in 2005 by May-Britt and Edvard Moser, grid cells lay the foundation for building mental maps of your surroundings and for tracking your precise positions within these landscapes. As you move around your environment, your movements are being followed by grid cells on an internal map.

But now it turns out that grid cells also perform rapid, rhythmic sweeps into the space ahead of the animal. These sweeps act almost like an antenna, allowing the animal to probe the environment ahead of it. This revelation reshapes our understanding of spatial navigation in the brain.

Beyond the Brain's GPS: A Hidden Pattern Emerges
Scientists have long believed that grid cells acted like a GPS pin, faithfully marking a location at any time.

But the Kavli Institute researchers found a much more dynamic process at play: Grid cells alternate between tracking an animal's real-time position and scanning the environment ahead in a highly regular pattern–sweeping 30 degrees to the right, then 30 degrees to the left–at a rapid pace of ten times per second.

These rhythmic sweeps create a more efficient way to anchor locations relative to one another, providing a richer and more adaptable navigation system than previously imagined.

This breakthrough, made by researchers Abraham Zelalem Vollan, Rich Gardner, May-Britt Moser, and Edvard Moser, was published in *Nature* on February 3, 2025.

New technology provided new insight
For decades, these sweeps remained undetected, trapped inside minuscule pockets of time in the grid cell data.

The reason? Technological limitations.

Past recording tools lacked the capacity and temporal resolution to show the rapid fluxes within the large-scale coordination of whole populations of grid cells in real time.

That changed with the introduction of *Neuropixels 2.0*–a revolu-tionary neurotechnology capable of recording thousands of neural interactions with millisecond precision.

Scan this QR code with your mobile camera to see a video where Rich Gardner and Abraham Vollan at the Kavli Institute demonstrate Neuropixels 2.0

The Secret of Grid Cells
"Previous research studies at the Kavli Institute have identified the components of the sense of place, such as cell types and neural circuits involved. What we wanted to find out was how the mental maps are used in real-time," Gardner said.

He said that understanding the dynamics, processes, and changes that happen in the overall neural activity in the network can show how the brain actually uses this machinery for navigation.

Gardner and Vollan at one of the boxes the rat navigated during the experiments. Photo: Rita Elmkvist Nilsen / Kavli Institute.

Sveipene som overrasker hjerneforskere

Nytt forskningsgjennombrudd ved Kavli-instituttet avdekker en aktivitet i gittercellene som antar en følehornlignende form. Den benytter rottene til å sondere omgivelsene omkring seg.

I 2005 oppdaget forskerparet May-Britt Moser og Edvard Moser gittercellene og hjernens stedsans. Gittercellene fungerer som hjernens GPS.

De bygger grunnmuren for mentale kart over landskapene du beveger deg i, og de sporer din nøyaktige posisjon i dette landskapet. Når du beveger deg rundt i omgivelsene dine, følges bevegelsene dine av gittercellene rundt på det indre, mentale kartet.

Gittercellenes hemmelighet
Frem til i dag har forskerne trodd at gittercellene er som en GPS-nål som trofast markerer hvor du til enhver tid befinner deg. Det nye forskningsfunnet ved Kavli-instituttet på NTNU avslører at gittercellene gjør mer enn det. De veksler mellom å spore egen-lokasjon og å utforske omkringliggende steder.

Ti ganger i sekundet samhandler gittercellene om å sende sveipende sonderinger ut i rommet foran dyret i et svært regelmessig mønster, vekselvis 30 grader mot høyre og 30 grader mot venstre. Sveipene avdekker en langt mer effektiv måte å kartlegge omgivelser og å forankre lokasjoner i forhold til hverandre og en selv.

Sveipene ble oppdaget i rotter av forskerne Abraham Zelalem Vollan, Rich Gardner, May-Britt Moser og Edvard Moser, og forskningen er publisert i *Nature* 3. februar 2025.

Ny nevroteknologi ga ny innsikt
Sveipene har vært der hele tiden, men de har ligget skjult inni gitterfeltene, fanget i tidslommer som var for små til å bli registrert.

Bremsen lå på teknologisiden. Forskningsutstyret som var tilgjengelig kun få år tilbake, kunne hverken registrere fra tilstrekkelig antall celler eller i en tidsoppløsning god nok til å avdekke sveipene.

En revolusjonerende nevroteknologi kalt Neuropixels 2.0 snudde om på dette.

Skann denne QR-koden med mobilkameraet ditt for å se Rich Gardner og Abraham Vollan ved Kavli-instituttet vise frem Neuropixels 2.0

Forskere ved et utenlandsk laboratorium hadde funnet hjerneaktivitet som antydet at gittercellene kanskje ikke bare var opptatt av å følge dyret som en kompass-nål, men at de også var opptatt av mål, steder dyret ønsket å gå.

Dette ville Kavli-forskerne finne ut av.

Et sveip varer 125 millisekunder
– Tidligere forskningsstudier på Kavli-instituttet har identifisert komponentene i stedsansen, slik som celletyper og nevrale kretser som er involvert. Vi ønsket å finne ut av hvordan de mentale kartene blir brukt i sanntid, forteller Rich Gardner.

– Hvilke dynamikker, prosesser og endringer finner sted i den samlede nevrale aktiviteten i nettverket, som kan avsløre hvordan hjernen faktisk bruker dette maskineriet til navigasjon, forklarer han.

Metoden forskerne brukte for å teste dette kalles dekoding. Et sveip varer 125 millisekunder, og tilsvarer en thetabølge i hjernedataene.

Den nye Neuropixels-proben kan registrere samhandlinger fra tusenvis av celler i hele nettverket ned på millisekundnivå, mens rotta navigerer i våken tilstand, er i REM-søvn, eller i dypsøvn.

For hver tidsblokk av hjernedata som neuropixels-proben lastet opp i datamaskinen, dekodet datamaskinen hvilken lokasjon som rottas gitterceller i det indre mentale kartet var opptatt av. Så korrelerte datamaskinen denne kartlokasjonen fra gittercellene med rottas faktiske lokasjon i det fysiske landskapet.

To understand exactly what has going on, the researchers used a method called decoding. A sweep lasts 125 milliseconds and corresponds to what is called a theta wave in brain data.

The new Neuropixels probe can record interactions from thousands of cells across the network down to the millisecond level while the rat navigates in an awake state, is in REM sleep, or in deep sleep.

For each time block of brain data uploaded by the probe, the computer decoded which mental-map-location the rat's grid cells were focused on. The computer then correlated the grid cells' mental map location with the rat's actual location in the physical landscape

Scan this QR code with your mobile camera to see what the Kavli researchers can see on their computer screens during the experiment. On the video you can see the rat navigating in the box, while you simultaneously hear and see the activity of thousands of grid cells as they are interacting in real-time to form the rat's mental map and sense of place. Recording: Abraham Vollan /Kavli Institute.

Using the new Neuropixels probe, researchers decoded how a rat's mental map dynamically shifts during navigation.

To their astonishment, they found that the map did not perfectly align with the rat's actual location.

Instead, the map was out of sync with the rat's location in a very regular manner. Deep in the millisecond timescale, the grid cells sent waves of neural activity through a series of grid cells coding for neighbouring locations in an outwards movement.

The sweeps start powerfully with the grid cells coding for the rat's actual location in space, sweeping forward to the right, die out at the furthest end of the sweep, before the sweeps emerge anew at the rat's position, sweeping out to the other side.

These rhythmic sweeps suggest that grid cells do more than simply pinpoint the animal's position–they actively explore the environment in real-time, continuously updating its internal representation of space.

Scan this QR code with your mobile camera to see what the neural activity of sweeps as they scan the environment, overlaid simultaneously on a video of the rat as it navigates in a box. Video: Abraham Vollan and Rich Gardner / Kavli Institute.

"In the old research data, this entire dynamic is merged into the large, fat grid fields we know," says May-Britt.

"When we subtract sweeping data from cell activity coding for the rat's self-location, the grid fields become smaller and more precise," she said.

Nature's optimal strategy?
Why do grid cells scan the environment in this particular way? And why the specific angle, length and alternating pattern?

The answer may lie in nature itself.

"Some bat species use echolocation to navigate, emitting sound waves in alternating directions to scan their surroundings," said Edvard Moser. "This pattern is a strikingly similar to that of grid cell sweeps."

He uses his hands to show how the coordinated grid signal shoots out from the forehead like focused spotlights, alternating to the right and left.

The brain's doughnut-shaped mental map
The length of the sweeps could be explained by previous findings: our mental maps are doughnut-shaped.

"Sweeps extend up to half a loop around the doughnut-shaped map, and never beyond. This way, grid cells avoid overlapping into other areas of the mental map," Abraham Vollan said.

The distance covered by sweeps is thus limited by the brain's own doughnut-shaped rule for how grid cells are allowed to act within the brain's GPS.

The brain has at least three to five different modules of grid cells in the brain, corresponding to three to five different doughnut-shaped mental maps, each tasked with covering different scales of space.

The sweeps travel the same distance on all doughnut-shaped maps. But since the mental maps relate to physical space in different scales, the grid cells that build our large-scale maps cover larger distances in our physical landscape than grid cells that generate more precise small-scale maps.

Scan this QR code with your mobile camera to see what the sweeps look like on one of the doughnuts (toruses) of interacting grid cells.
Video: Rich Gardner / Kavli Institute

To find the explanation for why the brain prefers to scan the surroundings with these narrow antenna-like sweeps, Gardner built an artificial agent (a computer model based on artificial intelligence).

The small"robot" tested different ways to map an area it moved through and found that the optimal strategy followed a characteristic herringbone pattern.

Scan this QR code with your mobile camera to see the little agent scan its environment applying the same herringbone pattern as the rat.

Skann denne QR-koden med mobilkameraet ditt for å se hva Kavli-forskerne kan se på sine dataskjermer under eksperimentet. Nede til høyre ser de direktestrømmet video av hvordan rotta navigerer i boksen. Samtidig kan de se og høre aktiviteten til tusenvis av gitterceller i sanntid som samhandler om å danne rottas mentale kart og stedsans. Opptak: Abraham Vollan / Kavli-instituttet

Til forskernes overraskelse var kartet ikke alltid i samsvar med landskapet. Tvert imot var kartet i utakt med hvor rotta befant seg på en veldig regelmessig måte.

Dypt nede i millisekundtid ble det synlig at gittercellene sender en liten bølge av nevral aktivitet gjennom en rekke gittercellene som markerer for nabo-områder i landskapet. Gittercellene gjør altså et kart-sveip gjennom omgivelsene.

Sveipen starter kraftfullt i gittercellene som markerer for rottas faktiske lokasjon i rommet, men så flytter den koordinerte gittercelle-aktiviteten seg hurtig fra rotta og fremover til høyre eller venstre i det mentale kartet, før signalet dør ut.

Deretter starter signalet på ny opp ved rottas posisjon, for så å sveipe ut til den andre siden, og slik veksler sveipene taktfast mellom høyre og venstre. Gittercellene i rottas mentale kart, kodet altså ikke bare for rottas posisjon, men også for nærliggende områder av landskapet rotta befant seg i, på en veldig regelmessig måte.

Skann denne QR-koden med mobilkameraet ditt for å se hvordan sveipene ser ut! Her ser du hva som foregår i den ytre virkeligheten samtidig som du ser hva som foregår inni rottas mentale kart. Gittercellene i hjernen til rotta samarbeider om å lage lange sveip ut fra rottas faktiske posisjon i landskapet. Sveipene sonderer omgivelsene, og hjelper rotta å relatere ulike steder til hverandre. Video: Abraham Vollan og Rich Gardner / Kavli-instituttet

– I de gamle forskningsdataene er hele denne dynamikken slått sammen til de store, fete gitterfeltene vi kjenner, sier May-Britt Moser.

– Når vi trekker fra data som tilhører sveipene og kun sitter igjen med øvrig gittercelleaktivitet som koder for rottas egenlokasjon, blir gitterfeltene mye mindre og mye mer presise, forklarer hun.

Naturens optimale strategi?
Hvorfor i all verden holder gittercellene på med dette da, spurte forskerne seg. Og er det noe spesielt med akkurat denne lengden, to-sidigheten, og denne 30-graders vinkelen som alternerer mellom høyre og venstre?

– De nyoppdagede sveipene beveger seg i et mønster som er likt det vi kjenner fra flaggermus, forteller Edvard Moser.

– Noen flaggermus-arter navigerer ved hjelp av ekkolokasjon. De kartlegger omgivelsene sine ved å sende ut lydsignaler vekselvis til venstre og høyre.

– Akkurat den samme dynamikken ser vi i populasjonen av gitterceller når de sonderer dyrets omgivelser med slike lange sveip som alternerer mellom venstre og høyre, sier Moser.

Forklaringen på sveipenes lengde fant forskerne i tidligere funn: de mentale kartene hjernen vår lager over landskap er smultringformede.

– Det vi ser er at sveipene skyter aldri lenger ut enn halvveis rundt smultring-kartet. På den måten unngår gittercellene overlapp inn i andre områder i det mentale kartet, forklarer Abraham Vollan.

Lengden sveipene kan dekke er altså begrenset av hjernens egen smultringformede regel for hvordan gittercellene får lov å være aktive i hjerne-GPS-en. Vi har minst tre til fem ulike moduler av gitterceller i hjernen. Disse tilsvarer tre til fem ulike smultringformede mentale kart i hjernen, som har som oppgave å dekke ulike målestokker av rom.

Sveipene beveger seg like langt på alle de smultringformede kartene. Men siden skalaen mellom det fysiske rommet og hver av de mentale kartene er forskjellig, så vil gittercellene som bygger de store kartene våre, sveipe mye lenger frem i det fysiske landskapet vi utforsker, enn gitterceller som bygger de mer presise småskala-kartene.

Skann denne QR-koden med mobilkameraet ditt for å se hvordan sveipene beveger seg over det smultring-formede mentale kartet av gitterceller som samhandler. Video: Rich Gardner / Kavli-instituttet

For å finne forklaringen på hvorfor hjernen foretrekker å skanne omgivelsene i nettopp disse smale følehorn-lignende sveipene, tosidig med 30 graders vinkel, alternerende ut til høyre og venstre, bygget Rich Gardner en simulert robot (en datamodell basert på kunstig intelligens).

Det den lille roboten testet ulike måter å kartlegge et område som den beveger seg gjennom. Den kom frem til at den optimale strategien fulgte en karakteristisk fiskebeinsmønstret dynamikk. Dette er akkurat den samme regelen som sveipene i rottehjernen benytter seg av: høyre, venstre, høyre i 30-graders vinkel.

Denne strategien viser seg altså å være den aller mest effektive for å kartlegge et område på kortest mulig tid og med minimalt av overlapp.

Skann denne QR-koden med mobilkameraet ditt for å se hvordan den lille roboten sender fiskebeinsmønstrede sonderinger ut i omgivelsene sine, på samme måte som rotta gjør.

It arrived at exactly the same rule as the sweeps in the rat brain: right, left, right at a 30-degree angle. This strategy turns out to be the most efficient for mapping an area in the shortest possible time with minimal overlap.

"If we look at echolocation in bats, antennae, whiskers, or our eyes located on each side of the skull, we recognize a principle where these two alternating angles for sampling or probing space recur," Gardner said.

The computer model arrived at exactly the same principle for optimal mapping.

"It makes sense to think that evolution would have positioned our sensory organs and mental faculties in a way that exploits this principle," he said.

Sweeps Are a Rule Hardcoded in Our Brain
The researchers found sweeps both when the rat navigated and in REM sleep when the rat did not receive sensory input from the outside world.

"Maybe it's navigating in its dreams," Edvard Moser said. During deep sleep, a state where the brain does not generate theta waves, the sweeps were rarer and more irregular.

"The sweeps also probe over cliffs and through walls, so it's clear that the signal is not primarily about where the rat plans to go," May-Britt Moser said.

"The vector principle in the sweeps suggests that the sweeps may be a way to build more robust maps. The precise scans contain very systematic information about direction and distance to places and may be a way for the brain not only to focus on individual locations, but also to relate and anchor these places to their surrounding environments," Gardner said.

Edvard Moser said that the results suggest that the sweeps could be a fundamental mechanism hardcoded into the network – a kind of brain algorithm.

"What I think we have found is a repetitive and stereotypical process that continuously occurs in the brain's mental maps, helping to map the surroundings of a rat running around," Vollan added.

This map may be important for recalling memories of the rat's surroundings and for creating new maps of environments the rat has not been in before, he said.

Do Humans Sweep, Too?
The study was conducted in rats, but might a similar mechanism exist in humans?

Given that we share the same brain structures, cell types, and rhythmic neural processes, the researchers believe this is likely.

"I believe you will find something similar to sweeps in humans too," Vollan said.

"We have the same brain areas, cell types, the same functions such as memory and navigation, and we also have this rhythm, albeit a bit weaker. So, the question is whether we will see the exact same pattern? Humans, for example, are more visually driven. We can use our gaze to explore places at a distance," he said.

Perhaps the sweeps in humans are more closely tied to where an individual directs their gaze in space.

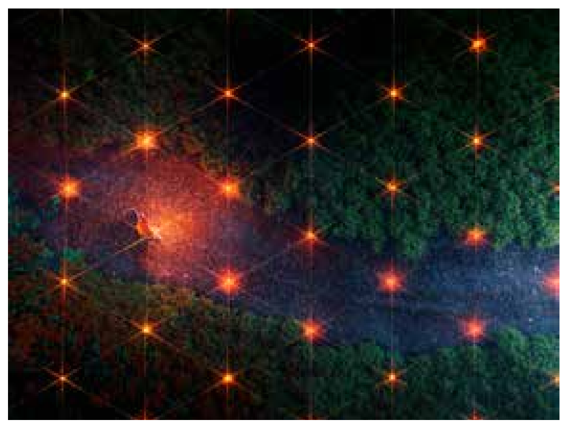
Researchers have found visual place cells in both birds and monkeys, which are activated depending on where they look.

So, the place cell fires not where the animal is, but where the animal's attention is focused.

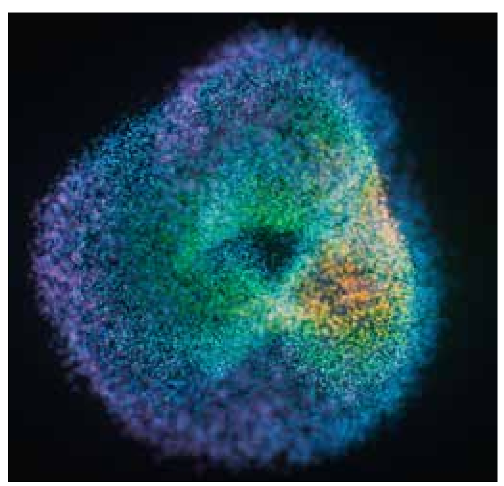
"Sweeps are a fundamental mechanism at the cell population level that can begin to explain this focus," Vollan said.

The many shapes of grid cells
"Previously, we have shown that grid cells have a geometry in space—the hexagonal coordinate system. They also have a geometry in network activity—the donut. And now we have found that grid cells also have a geometry in time," Edvard Moser said.

Here's the hexagonal coordinate system:



Here's what the doughnut looks like:



Both images: Helmet / Rita Elmkvist Nilsen, Kavli Institute.

– Om vi ser til ekkolokasjon hos flaggermus, følehorn, antenner, værhår, eller øynene våre som er lokalisert på hver side i skallen, så gjenkjenner vi et slags prinsipp der disse to alternerende vinklene for å sondere rom går igjen, sier Richard Gardner.

– Modellen vår kom frem til akkurat samme prinsippet for optimal kartlegging. Det gir mening å tenke at evolusjonen ville ha posisjonert sanseorganene og de mentale egenskapene våre på en måte som utnytter dette prinsippet.

Sveipene er en regel som ligger hardkodet i hjernen vår
Forskerne fant sveip både når rotten navigerte, og i REM-søvn når rotta ikke mottar sanseinntrykk fra omverden.

– Kanskje navigerer den i drømmene sine, spekulerer Edvard Moser. Under dypsøvn, en tilstand der hjernen ikke genererer thetabølger, ble sveipene sjeldnere og mer uregelmessige.

– Sveipene sonderer også ut over stup og gjennom vegger. Så det er helt tydelig at signalet ikke først og fremst handler om hvor rotta planlegger å gå, forteller May-Britt Moser.

– Vektorprinsippet i sveipene antyder at sveipene kan være en måte å bygge mer robuste kart på. De presise skanningene inneholder svært systematisk informasjon om retning og avstand til steder. Skanningene kan derfor være en måte som hjernen ikke bare fokuserer på enkelt-lokasjoner, men også relaterer og forankrer disse steder til deres omkringliggende miljøer, anslår Rich Gardner.

– Samlet, peker resultatene i retning av at sveipene er en grunnleggende mekanisme som er hardkodet inn i nettverket. En såkalt hjernealgoritme, sier Edvard Moser.

– Det jeg tenker vi har funnet er en repetitiv og stereotypisk prosess. Den foregår kontinuerlig i hjernens mentale kart, og er med på å kartlegge omgivelsene til en rotte som løper rundt, sier Abraham Vollan.

Sveiper mennesker også?
– Dette kartet kan være viktig for å gjenkalle minner om omgivelsene til rotta, og for å danne nye kart over omgivelser som rotta ikke har vært i før, sier han.

Funnet er gjort i rotter. Mange lurer sikkert på om vi også går rundt og sveiper hele tiden.

– Jeg tror man vil finne noe som ligner sveip i mennesker og. Vi har de samme hjerneområdene, celletypene, de samme funksjonene som hukommelse og stedsans. Og vi har også denne rytmen, om enn litt svakere. Så er spørsmålet om vi vil se nøyaktig det samme mønstret? Mennesker er for eksempel mer visuelt drevet. Vi kan bruke blikket vårt til å utforske steder på avstand.

– Kan hende er sveipene hos mennesker knyttet tettere opp til hvor man ser på i rommet. Forskere har blant annet funnet visuelle plass-celler i både fugler og aper, som aktiveres avhengig av der de ser.

– Så plass-cellen fyrer av ikke der dyret befinner seg, men der oppmerksomheten til dyret er fokusert. Sveipene er en grunnleggende mekanisme på cellepopulasjonsnivå som kan begynne å forklare dette fokuset.

Gittercellenes former
Fra før har forskerne vist at gittercellene har en geometri i rom – det heksagonale koordinatsystemet. Se øverste bilde på foregående side. Og en geometri i nettverksaktivitet – smultringen, se nederste bilde på foregående side

– Nå har vi funnet at gittercellene også har en geometri i tid, sier Edvard Moser (se video under).

Skann denne QR-koden med mobilkameraet ditt for å se hvordan gittermønsteret pulserer når gittercellene sveiper ut foran rotta for å sondere terrenget. Video: Abraham Vollan og Rich Gardner/ Kavli-instituttet

– Sveipene endrer vår ide om gittercellene og navigasjon i den forstand at vi nå vet at gittercellene ikke kun koder nåværende posisjon isolert. De relaterer også disse posi-sjonene til hver omkringliggende posisjon, nøyaktig kodet inn i det mentale kartet.

Fortsatt er mange spørsmål ubesvart, og Kavli-forskerne har ikke tenkt å slippe tak i sveipene med det første.

– Vi er allerede i gang med flere studier som vil gi nye svar på tingene vi klør etter å finne ut av, ler May-Britt Moser.

Sju lange år med beintøff forskning ble belønnet med bobler i glasset og publisering i Nature.

– Vår veileder Per Andersen lærte oss å feire seierne våre sammen. Den tradisjonen har vi tatt med oss til Kavli-instituttet, forteller May-Britt Moser.

– I dag feirer vi ikke bare fremragende forskning, men også et sjeldent godt forskersamarbeid. Det har vært en glede å samarbeide med så fine, rause og dyktige unge forskere som Rich og Abraham, sier hun.

Referanse
Abraham Z. Vollan, Richard J. Gardner, May-Britt Moser & Edvard I. Moser: Left–right-alternating theta sweeps in entorhinal–hippocampal maps of space. *Nature* 3. februar 2025

And here's how the grid cells have a geometry in time:

Scan this QR code with your mobile camera to see the pulse of the hexagonal grid pattern, as grid cells sweep out in front of the rat to probe the terrain. Video:Kavli Institute

"The sweeps change our idea of grid cells and navigation in the sense that we now know that grid cells don't just code for the current position in isolation but also relate these positions to each surrounding position, precisely coded into the mental map," Edvard Moser said.

Many questions remain unanswered, and the Kavli researchers do not intend to let go of the sweeps anytime soon.

"We are already working on several studies that will provide new answers to the things we are itching to find out," May-Britt Moser said.

Seven long years of tough research were rewarded with a champagne toast and a publication in Nature.

"Our mentor Per Andersen taught us to celebrate our victories together. We have brought that tradition with us to the Kavli Institute," said May-Britt Moser.

"Today we celebrate not only excellent research but also a good research collaboration. It has been a pleasure to work with such fine, generous, and talented young researchers as Rich and Abraham," she said.

Reference:

Vollan, A.Z., Gardner, R.J., Moser, MB. et al. Left–right-alternating theta sweeps in entorhinal–hippocampal maps of space. *Nature* (2025). https://doi.org/10.1038/s41586-024-08527-1

The researchers behind the study, from left: Professor of Neuroscience May-Britt Moser; research fellow Abraham Zelalem Vollan; Solberg fellow Rich Gardner; and Professor of Neuroscience Edvard Moser. Photo: Rita Elmkvist Nilsen / Kavli Institute.

Public outreach

Arendalsuka is Norway's largest political gathering. In 2024, the Kavli Institute took part in this political arena with a clear mission: to highlight the value of fundamental research and strengthen public trust in science-based facts. Their message was unequivocal–brain research requires political commitment and financial support!

NORBRAIN4 and the future of Norwegian brain research

On an otherwise quiet September morning, excitement rippled through neuroscience labs and hospital clinics across Norway. The Norwegian Research Council had just announced funding for the groundbreaking NORBRAIN4 project.

If you dig into the details, you'll find a wealth of dense scientific descriptions about the national initiative called NORBRAIN4. But what is it? A few brave souls who enjoy catching up on science reached out with questions about why this funding is such a game-changer for Norwegian brain science? Let's try to break it down.

The big questions of life require big data

Every day, Norwegian neuroscience labs generate data to help answer some of humanity's most profound questions, such as: How does our higher mental brain functions emerge from a network of chattering neurons. Are we born with a set nature, or are we shaped entirely by experience? Do we enter the world as blank slates, or do we already possess highly specialized abilities just waiting to be activated? What set of rules and recipes does the brain follow that still today make our minds so much more versatile and efficient than computers?

Right now, a revolution is unfolding in neuroscience, driven by rapid advancements in technology. For decades, technological limitations have dictated the scale of questions scientists could ask about the brain. For over sixty years, researchers have been refining variations of the same tools. Until now. A wave of technological breakthroughs is reshaping brain science, upgrading the entire research toolkit. These new instruments collect richer data, offering higher-resolution insights into brain activity across larger scales, spanning entire brain regions or even multiple areas simultaneously.

Tooling up

More data isn't just about volume; sometimes, it pushes us past critical thresholds that lead to entirely new ways of thinking. Where scientists once studied individual neurons in isolation, they can now observe vast networks of thousands of neurons interacting in real time while the brain actively solves complex tasks. Advanced imaging tools now capture the precise timing within neural conversations, revealing the intricate sequences that underlie our most complex cognitive functions. These same tools also shed light on when and where these conversations break down in neurological and psychiatric disorders.

EBRAINS – the Rosetta Stone of tomorrow's big data brain science

With great data comes great responsibility. Managing the sheer volume of research data is a challenge in itself. Previously, scientists could examine individual cells under a microscope. Now, they are bringing entire landscapes of neural activity into the lab. That's where EBRAINS, a European research infrastructure based at the University of Oslo (UiO), comes in. EBRAINS bridges the many research styles and languages across the fields and ensures that all neuroscience data and brain atlases are properly curated and shared globally according to the FAIR data principles (which is short for Findable, Accessible, Interoperable, Reusable).

Equipping Norway's neuroscientists and neurologists for the future

NORBRAIN4 guarantees that Norwegian researchers in labs and hospitals have access to cutting-edge technologies. At NTNU, the University of Oslo, and the University of Bergen, specialists are pioneering new imaging methods that capture brain activity at multiple levels: from full-brain scans to the neural networks driving cognition, all the way down to the breathtaking detail of individual synapses, molecules, and gene expressions within single cells.

The technological leap doesn't stop at observation. Tools that once only recorded brain activity can now actively stimulate it. New AI-powered analysis techniques are emerging, and revolutionary lab-based brain technologies - such as 7T MRI scanners and Neuropixels probes - are being adapted for clinical studies, bringing advanced neuroscience from research labs into Norwegian hospitals.

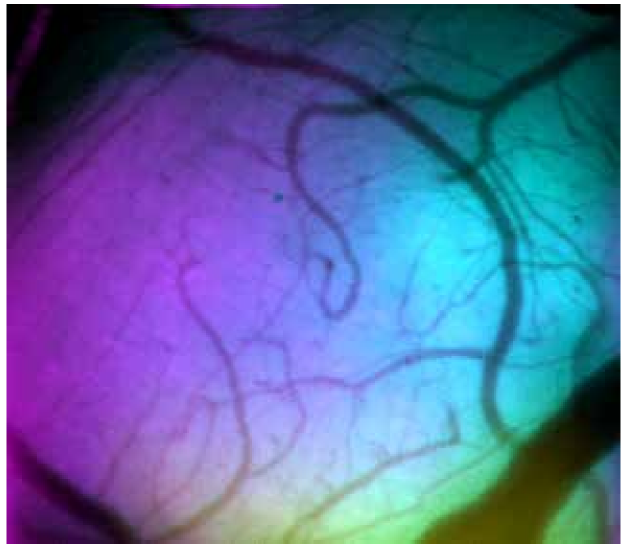


Image 1

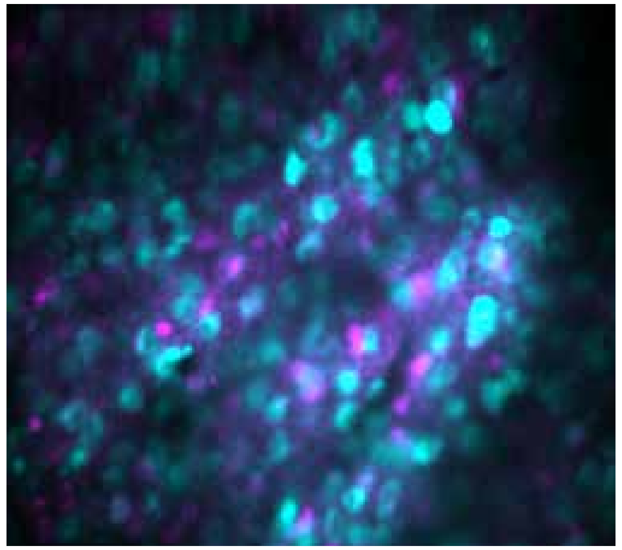


Image 2

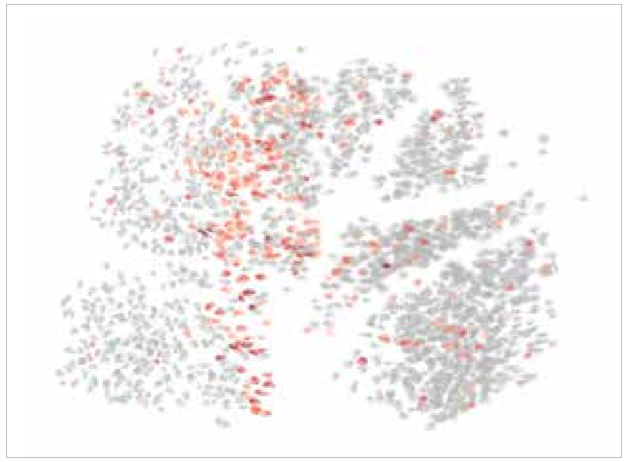


Image 3

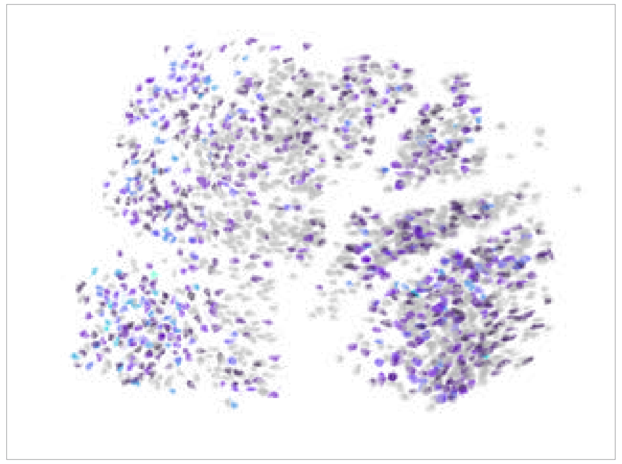


Image 4

All images credit: Martin Pofahl/Kavli Institute

The MINI2P - a window into the brain's inner workings

To see these advancements in action, check out images from one of NORBRAIN4's key technologies: the miniature microscope MINI2P.

Image 1: The brain on the screen glows in shades of violet, blue, and green, partially covered by swirling shadow-like patterns. These images are captured using a tiny, portable two-photon microscope - light enough for a mouse to carry on its head while effortlessly going about its daily activities.

What we see are two brain regions: the parasubiculum and the medial temporal cortex (MEC). MEC is home to the now-legendary grid cells, a discovery that earned the Mosers the Nobel Prize exactly ten years ago. Grid cells are also known as the brain's GPS, the internal measuring system for space. In the image, MEC, the region responsible for spatial awareness, glows yellow. Interneurons, which orchestrate the activity of larger groups of brain cells, appear in pink. Additionally, all active cells light up in blue. This blue activity is scattered throughout the image, blending yellow into green and pink into violet.

Look closely, and you can see the contours of the pink interneurons within the violet hues. The swirling black shadows are blood vessels. What you're seeing is a direct top-down view of the brain through a microprism.

Image 2: Here, we see the same brain cells viewed through a MINI2P microscope.

Image 3 shows a brain map of the MEC, captured by MINI2P. All grid cells (GPS cells) are marked in orange.

Image 4 shows the same brain map of the MEC, but in this visual, all head direction cells (compass cells) are marked in purple and blue.

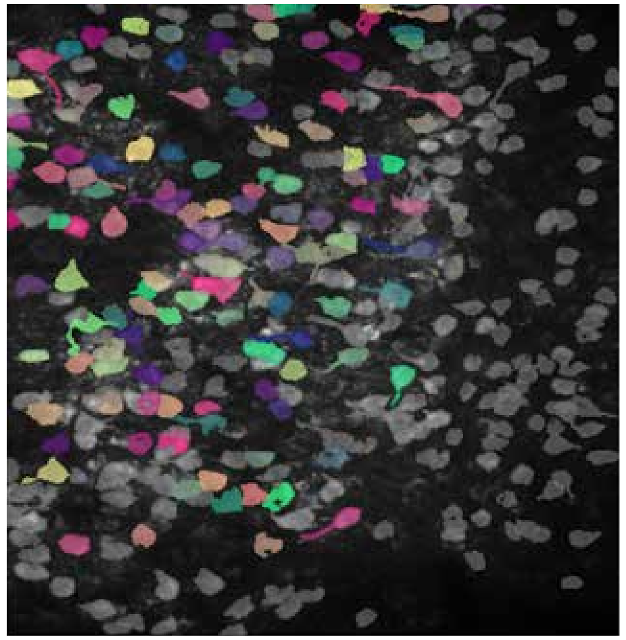


Image 5 *Image credit: Nienke de Jong/Kavli Institute*

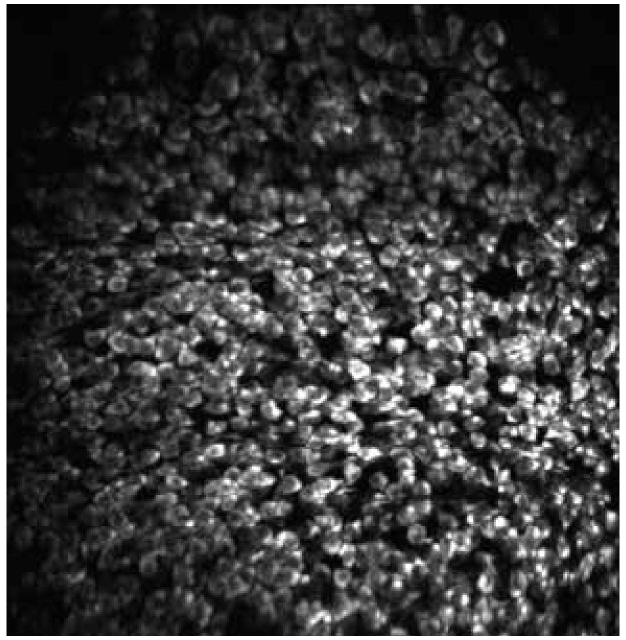


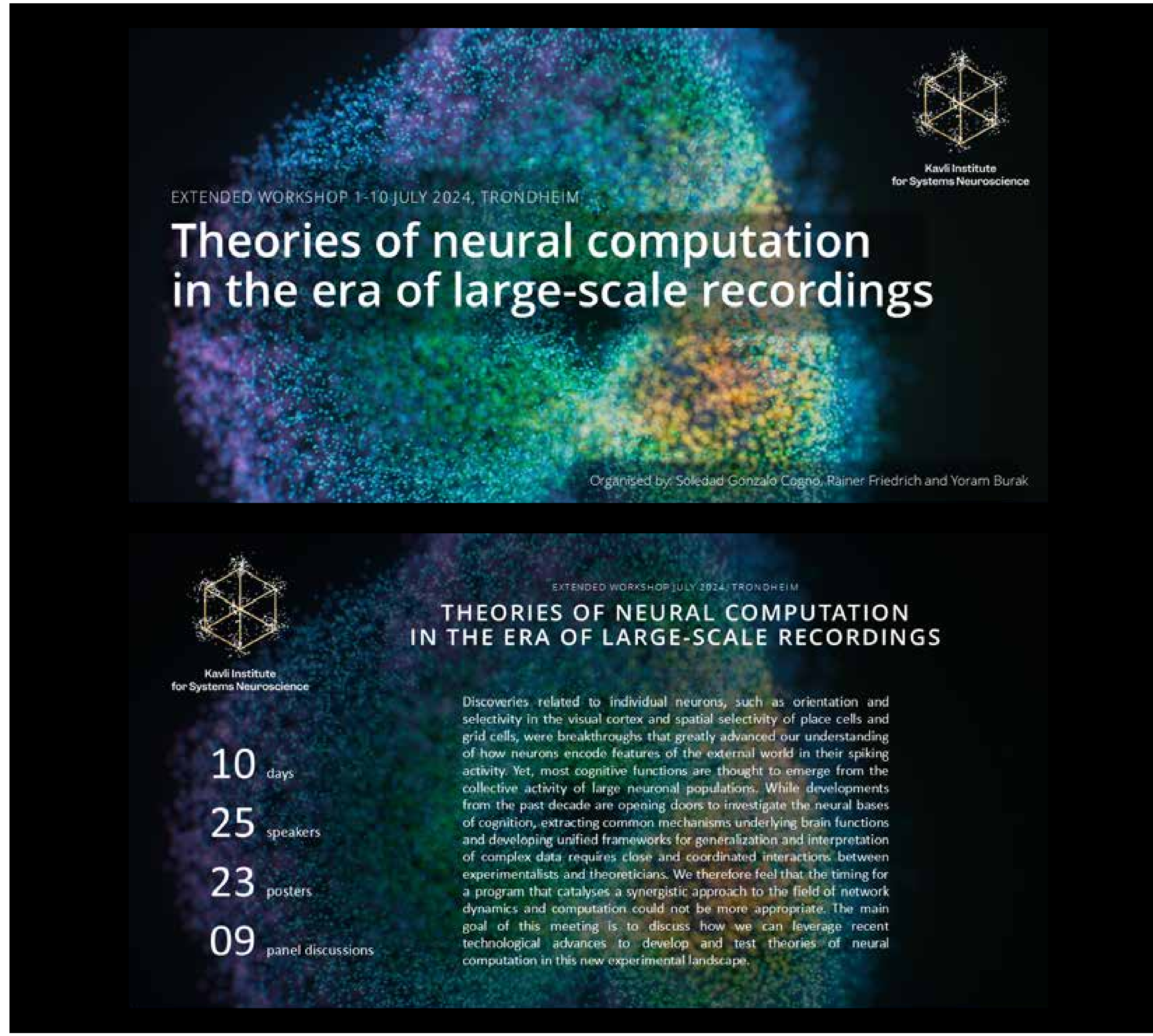
Image 6 *Image credit: Hanna Enequist/Kavli Institute*

Image 5: This is another type of map giving a different kind of information about grid cells in the MEC. Advanced technology has enabled researchers to colour-code the grid cells based on when and where they join the ongoing neural conversation. Here you see the conversation that allows grid cells to coordinate our sense of space. And remarkably, this grid cell conversation takes the shape of a donut, which you can see an image of in another part of this magazine. The colour codes in this image indicate where in the donut-shaped conversation each individual grid cell joins in and takes an active role.

Image 6: Here you see 1,067 neurons in the hippocampus, the brain area that collaborates closely with MEC and other areas to form our episodic memories many of which we will carry with us throughout life.

A new era for brain research
In short, NORBRAIN4 equips Norwegian neuroscientists with next-generation tools to investigate the complexities of brain function in both health and disease. It also ensures that Norwegian research data is shared with the global scientific community. This collaborative initiative between the University of Oslo, the University of Bergen, and NTNU is led by Edvard Moser and Bjarne Foss at NTNU's Kavli Institute.

International workshop organized in Trondheim



This was one of the best workshops I've attended. The timely topic, small size, and thoughtful blend of interactive theorists and experimentalists at different career stages made for exciting and useful discussions. Having just three long talks per day allowed those discussions to go much deeper than most conferences allow.

- Vivek Jayaraman, Janelia Research Campus, Howard Hughes Medical Institute

The KISN workshop has been wonderful: a perfect blend of experimentalists and theoreticians, with ample time for discussions, which allow new ideas to emerge. I myself went away with a couple of new ideas that emerged during the workshop, and which I will want to try out in the lab. The atmosphere was great and the organization impeccable -- I only wish you could organize another such workshop in the future .

- Nachum Ulanovsky, Weizmann Institute of Science

Thanks to the diverse perspectives featured in the workshop, which spanned multiple model systems and levels of analysis, I gained a deeper and more nuanced understanding of leading theories of neural computation.
A particularly outstanding feature of this workshop was the ample time allotted for discussion, which extended across both space and time! This helped me forge new connections with theoreticians and sparked ideas for concrete predictions I can test as an experimentalist.

- Frances Cho, Stanford University

I found the format and the duration of the scientific program especially engaging and motivating since we got to see prominent scientists of the field think and respond on their feet and not only present results but share and discuss foundational ideas behind their current work and their future plans. As a student, this was a very unique opportunity and left me with a sense of real excitement for the field and many new ideas.

- Nischal Mainali, Hebrew University of Jerusalem

Thanks a lot for the discussion and the very unique exceptionally successful workshop, which was highly informative, interactive and stimulating (as you saw, it stimulated a lot of equations....). And above all, you and the KISN team managed to foster a wonderful warm and fun atmosphere.
Looking forward to continued interaction.

- Haim Sompolinsky, Harvard University/Hebrew University of Jerusalen

Neuroscience research is undergoing a major transformation- our biggest challenge is no longer a lack of data, but the need for more abstract thinking to interpret the super complex datasets we're collecting. The KISN workshop taught me that our best strategy to understand higher-order brain function involves combining approaches from physics, math, and computer science with physiological insights and theory to guide the application of these methods.

- Jo Carpenter, Kavli Institute for Systems Neuroscience, NTNU

It has been an immense pleasure to organize this workshop with Soledad and Yoram, and with the support of Edvard. The format with talks interrupted by in-depth discussion has been an experiment that was, in my view, extremely successful, last not least due to the enthusiasm of the participants. I took away many new insights and inspirations from the crosstalk between experimentalists and theoreticians. This has been the most interactive meeting I ever attended - I thank all participants for that, and the staff at KISN for their tremendous support!

- Rainer Friedrich, Friedrich Miescher Intstitute for Biomedical Research

Our goal for the meeting was to discuss how the new experimental tools that emerged in the past decade could push forward the synthesis between theory and experiment in computational and systems neuroscience. I came out of the meeting with a new perspective on these questions, and many new ideas for my own research. I think that the long format of the lectures, in which questions and discussions were encouraged, worked very well. It was an absolute pleasure to work together with Soledad and Rainer on the scientific program, with the support of Edvard and the entire leadership of the Kavli Institute. The administrative team at the institute has done a superb job in the logistic organization, and this was key to the meeting's success. Finally, I am very thankful to all the participants for their intense engagement in the scientific discussion, and for the excellent talks and posters.

- Yoram Burak, Hebrew University of Jerusalem

It has been an absolute pleasure to organize this workshop together with Rainer and Yoram, and with the help and support of Edvard and the entire KISN team. Moreover, it has been an immense privilege, as a KISN member, to welcome all the speakers and participants to our institute. This event went beyond all my expectations. I enjoyed the long talks, the extended discussions, and the relaxed atmosphere – I'm full of new ideas! I thank all the participants for making this workshop such a memorable experience.

- Soledad Gonzalo Cogno, Kavli Institute for Systems Neuroscience, NTNU

HIKE TO STORFOSSEN

After long days of science, our group set off on a hike through the boreal rainforest of Homla Nature Reserve to Storfossen, a 40m high waterfall whose spray zone supports the survival of twelve red-listed and endangered species.

We were treated to an authentic mid-Norwegian experience. The rain was pouring down. The charming path that had promised to guide us safely through the steep terrain turned into a mudslide. Many a knee made a semi-controlled touch-down, but our spirits remained uplifted.

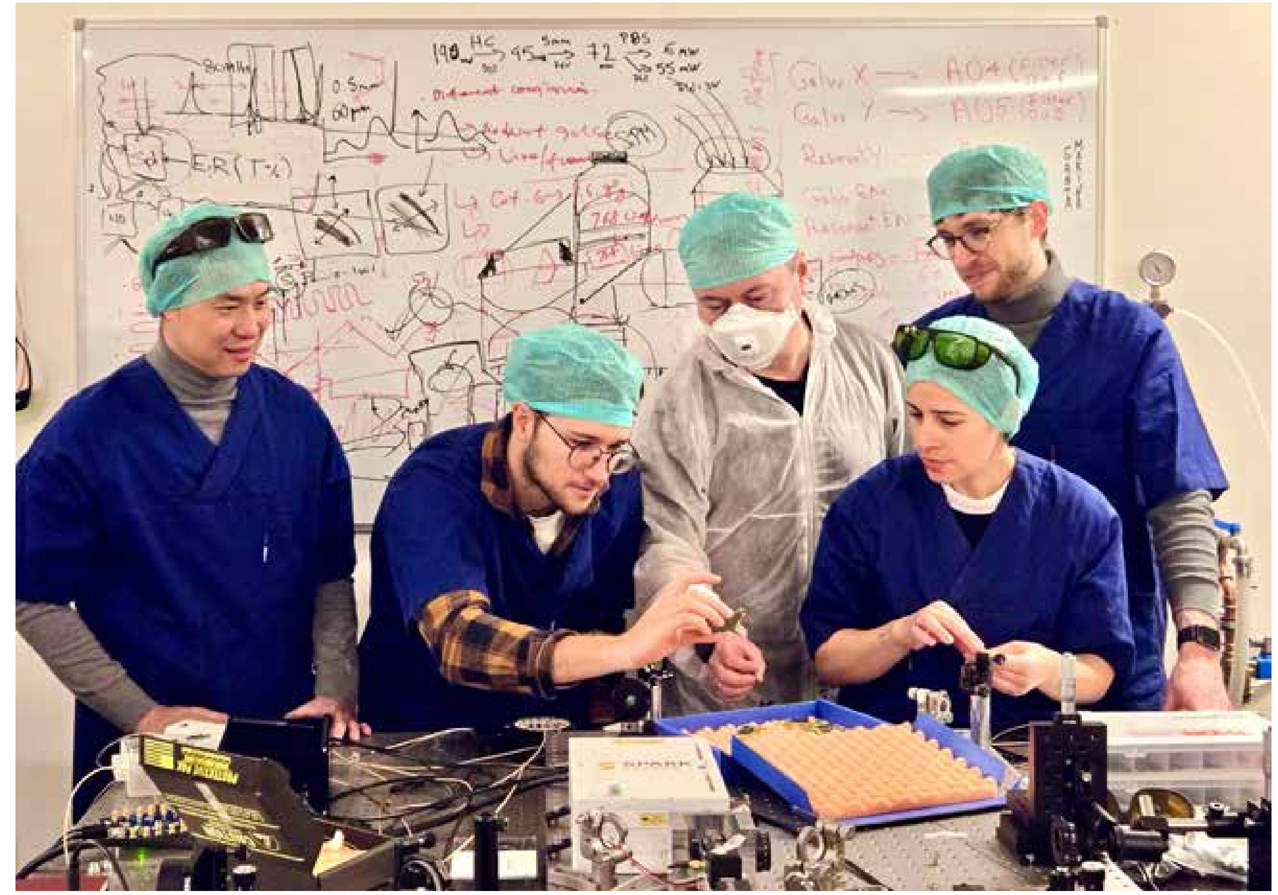
Zong Group: Seeing the mind in motion

Weijian Zong, group leader at the Kavli Institute, is recipient of a wFRIPRO grant for Early Career Researchers, and is together with his group of researchers awarded funding for the further development of MINI2P through the Verifisering programme, both by the Research Council of Norway.

The brain, an intricate network of billions of neurons, serves as the central hub for processing information and controlling complex behaviors. High-level cognitive functions–such as decision-making, social interaction, and navigation–emerge from the coordinated activity of large populations of neurons with distinct firing patterns and connections. However, our understanding of cognition has been significantly limited by the inability to simultaneously monitor the activity of sufficiently sized populations of neurons during animals' complex behaviors.

Two-photon (2P) microscopy has become one of the most powerful techniques for large-scale imaging of neuronal activity in behaving animals. A key limitation of this technology is that traditional 2P microscopes are large, requiring animals to be head-fixed under the objective lens for imaging, much like human subjects must be immobilized for MR or CT scanning. To overcome this constraint, researchers have tried to develop miniature 2P microscopes that can be mounted on freely moving animals, enabling the study of naturalistic behaviors. Despite significant technological advancements, miniature 2P microscopes were, until 2022, limited in throughput, with the typical number of neurons recorded simultaneously remaining at the level of dozens of cells –only a small fraction of the total neurons in a typical brain microcircuit. With the invention of MINI2P by Zong et al in 2022, a new era was opened. At a weight of less than 3 g, MINI2P made it possible to record more than a thousand neurons at the same time while mice were performing natural behaviors such as running and climbing.

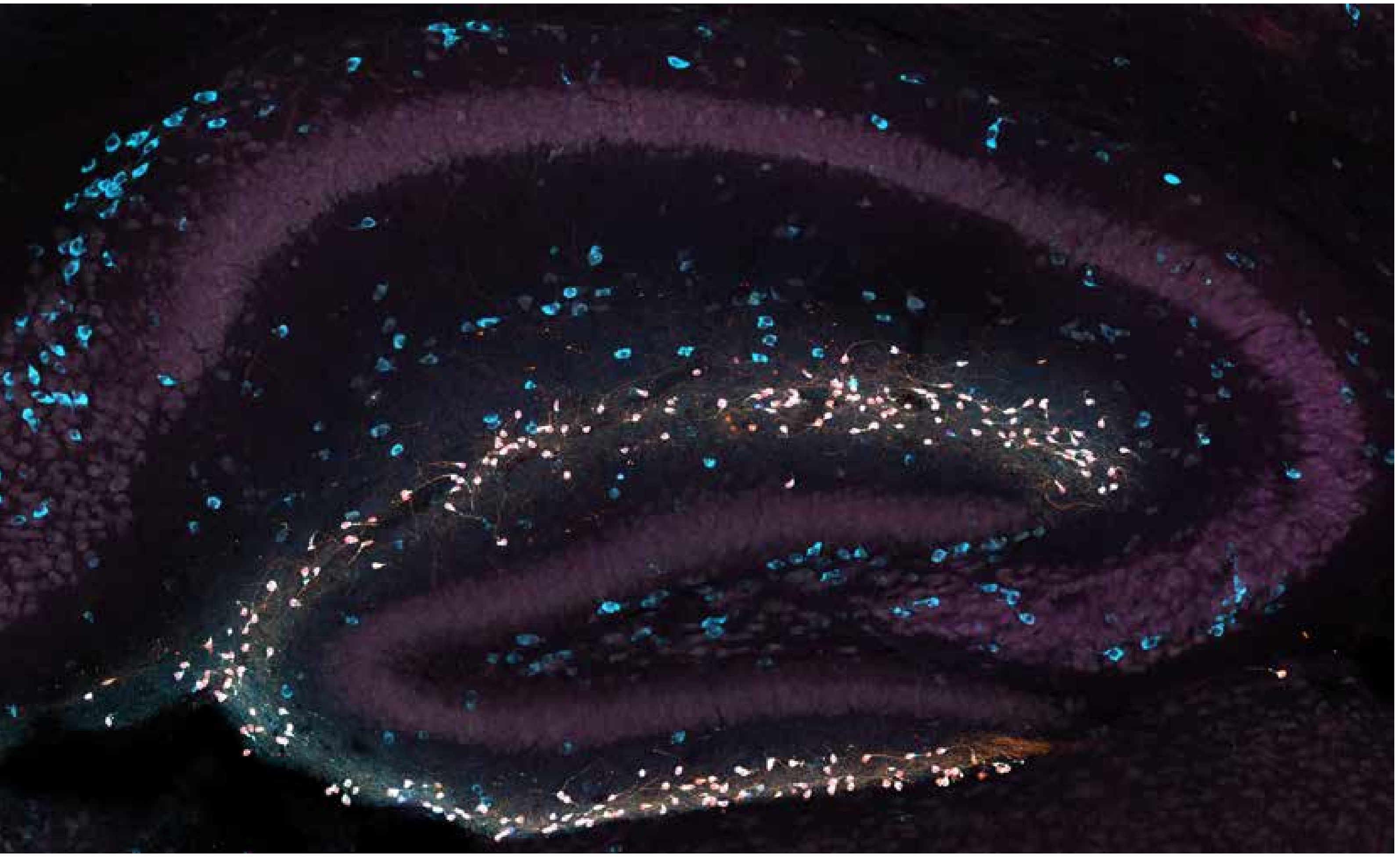
The Zong Group at the Kavli Institute aims to revolutionize the imaging of neural population activity in behaving animals by further developing the MINI2P project into a next-generation miniature 2P microscope. This system integrates several technological innovations that, when combined, increase the capacity to record neuronal activity to many thousands of neurons–a potential 10-fold improvement over the current state of the art. If successful, this breakthrough will enable an unprecedented scale of neural recording in freely moving animals, providing transformative insights into the fundamental computational principles underlying high-level cognitive brain functions.



Early life and the mysteries of brain development: The Quattrocolo Group's Quest

How do different types of neurons come together during development to form the intricate networks that allow us to learn, remember, and navigate the world? The Quattrocolo Group is on a mission to find out.

Giulia Quattrocolo, group leader at the Quattrocolo Group.



One of their biggest mysteries is the Cajal-Retzius cells - a fleeting, enigmatic neuron type that appears only in specific brain regions and vanishes soon after birth. But intriguingly, in some areas, these cells persist much longer. Why? What crucial role do they play in these regions?

To uncover the answers, the team is using an impressive array of cutting-edge techniques. They've developed a method to remove Cajal-Retzius cells early in postnatal development, allowing them to investigate how other hippocampal cells respond to their absence at the genetic level. They're also zooming in on synapses - the tiny but powerful structures that enable neurons to connect and communicate. Using mass spectrometry, they analyze the proteins within these synaptic connections, unlocking clues about how neural circuits mature.

But the story doesn't stop at the cellular level. The group is also exploring how the absence of Cajal-Retzius cells impacts behavior. By studying hippocampal functions like spatial navigation, learning, and memory, they're gaining insights into how these cells shape brain function. And thanks to support from the Brain and Behavior Research Foundation's NARSAD Young Investigator Award, they are now venturing into the realm of social behavior - an essential component of human interaction that is often disrupted in neurodevelopmental disorders like autism and schizophrenia. Could Cajal-Retzius cells hold the key to understanding these conditions?

Beyond this central research focus, the team is also pushing the boundaries of neuroscience by exploring other fundamental aspects of brain development, such as synaptic maturation and cell differentiation. These bold, high-risk projects are made possible through the generous support of the Kavli Foundation and NTNU's Stjerneprogram.

By diving deep into the mysteries of neural circuits, the Quattrocolo Group is shedding light on how the brain builds itself, and perhaps, uncovering clues that could one day help us understand and treat neurodevelopmental disorders.

***Sneak peek at upcoming publications:** This is a histology image of the mouse hippocampus. You can see the Cajal-Retzius cells (cells in white) in this P15 male mouse. Reelin is shown in cyan blue, p73 in magenta pink, and tdTom in orange. This transgenic Pdec1-Cre;NDNF-flox-flpO;TdTomato mouse was recently developed to specifically and selectively label and manipulate these cells. More exciting news about this research will hit Biorxiv this spring! Image courtesy of Kristian Moan from the Quattrocolo Group, Kavli Institute for Systems Neuroscience*

10 Years of the Nobel Prize (2014–2024)

THE LAB RACE

The Snapchat game The Lab Race was specially developed by NTNU Grafisk for the Nobel anniversary's research conference for youth. Open the Snapchat app and scan this QR code with your mobile camera to take part in the rat race!

In 2024, May-Britt Moser and Edvard Moser marked the 10th anniversary of receiving the Nobel Prize in Physiology or Medicine for their groundbreaking discovery of cell types that constitute the brain's sense of place–most famously, grid cells.

The milestone was celebrated with a research conference for youth at the Faculty of Natural Sciences, an international conference on research policy conference in the NTNU Rådsalen, and a grand jubilee concert in the magnificent Nidaros Cathedral. Through poetry, stunning light art by Pekka Stokke, and mesmerizing music from TrondheimSolistene, the John Pål Inderberg Trio, and others, the audience in Nidaros Cathedral was taken on an unforgettable artistic journey through space, time, and memory. The evening was masterfully guided by Karen Haugom Olsen, Petra Bjørkhaug, and Vegard Naustdal from the Church of Norway.

Adding to the festive spirit, Elgeseter Bridge in Trondheim was adorned with anniversary flags, while students and staff were treated to special "Nobel chocolate."

The celebration was a gift from NTNU, presented by Rector Tor Grande to honour May-Britt and Edvard Moser. Here, the Rector is seen sharing a cheerful conversation with the Nobel Laureates in Nidaros Cathedral.

Highlights

By studying the dynamics of grid cell populations, we have identified a sweep pattern in neural activity that may encode possible paths through space based on the current position (Vollan et al.). Additionally, we have shown that neural signals for body posture are interwoven with head direction dynamics in primary sensory areas (Mimica et al.). Two new research groups were established in 2023: the Gonzalo Cogno group and the Zong group. In 2024, Gonzalo Cogno and Moser discovered ultralow-frequency periodic sequences (Gonzalo Cogno et al.).

HIGH IMPACT PUBLICATIONS

Gonzalo Cogno S, Obenhaus HA, Lautrup A, Jacobsen RI, Clopath C, Andersson SO, Donato F, Moser M-B, Moser EI (2024). Minute-scale oscillatory sequences in medial entorhinal cortex. *Nature* 625, 338–344.

Vollan AZ, Gardner RJ, Moser M-B, Moser EI (2025). Left-right-alternating theta sweeps in entorhinal-hippocampal maps of space. *Nature*, AOP Feb 3. https://doi.org/10.1038/s41586-024- 08527-1

Mimica B, Tombaz T, Battistin C, Fuglstad JG, Dunn BA, Whitlock JR (2023). Behavioral decomposition reveals rich encoding structure employed across neocortex in rats. *Nat Commun* 14, 3947.

REKNOWNED GUEST PROFESSOR

Yoram Burak, Hebrew University of Jerusalem, Israel

LARGE INTERNATIONAL PROJECT

Edvard Moser

- Co-editor of Kandel´s Principles of Neural Science, 7th ed., to appear in 2027

INTERNATIONAL CONFERENCES ORGANIZED

Emre Yaksi

- Member of Scientific Program Committee FENS Forum 2024, incoming Chair for 2026

Soledad Gonzalo Cogno

- Workshop "Theories of neural computation in the era of large-scale recordings", Trondheim, juli 2024

PRIZES, HONORS, AWARDS, AND ELECTIONS TO REPUTABLE COMMITTEES

May-Britt Moser

- Foreign Member of the Royal Society of London

Edvard Moser

- Chair of the Kavli Prize Committee for Neuroscience
- Foreign Member of the Royal Society of London

Emre Yaksi

- EMBO member
- DKNVS Akademi member

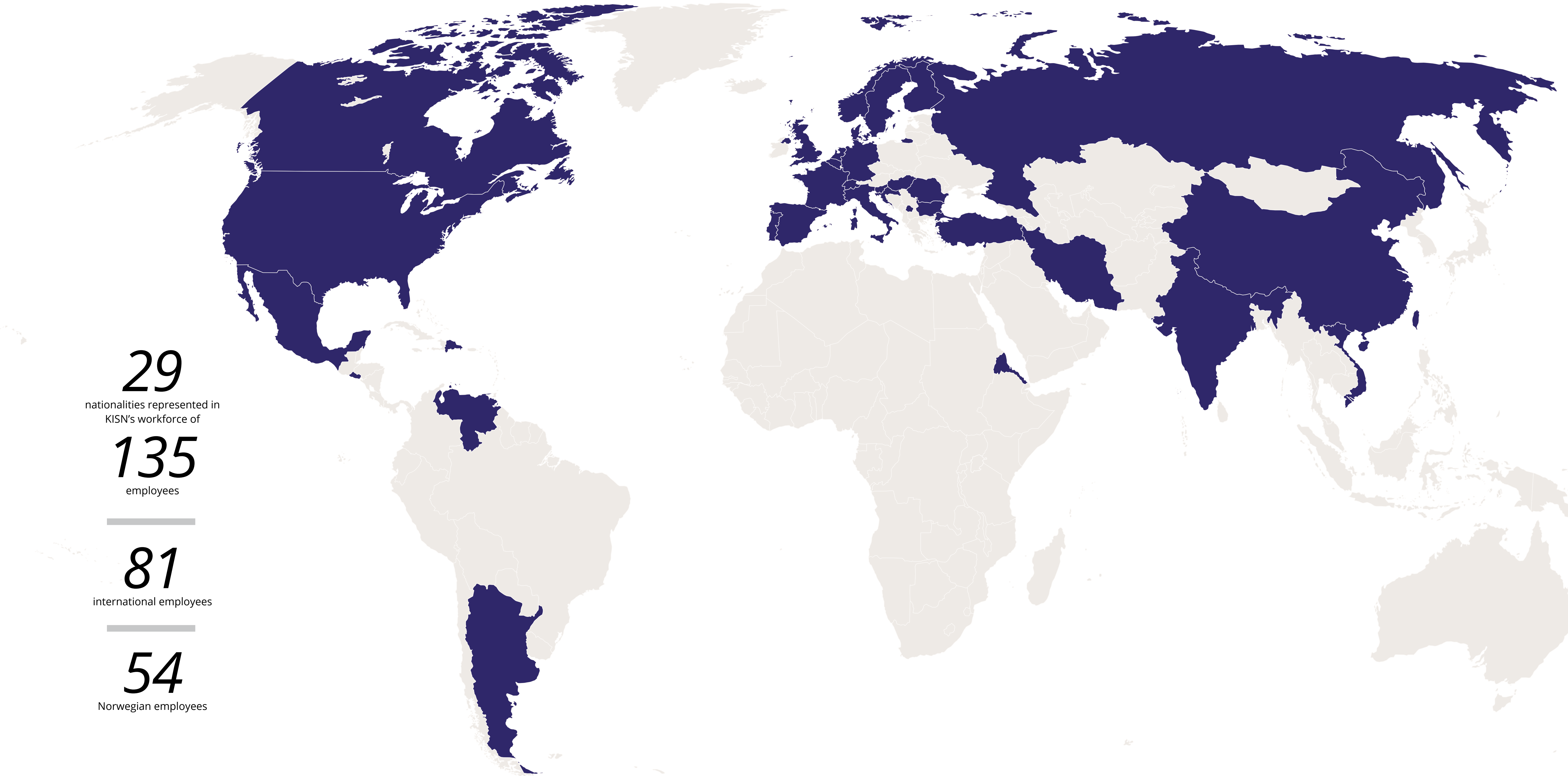
Jonathan Whitlock

- EMBO member

PHF DEFENCES CARRIED OUT AT KISN

Katrine Sjaastad Hanssen (f), Ida Välikangas Rautio (f), Emilie Ranheim Skytøen (f), Anne Nagelhus (f), Anna Maria Ostenrath (f), Ignacio Polti (m)

Facts



29

nationalities represented in KISN's workforce of

135

employees

81

international employees

54

Norwegian employees

Annual accounts

Actual Funding of All Academic Activities at the Centre for Algorithms in the Cortex (in thousand NOK)

	2023	2024	TOTAL SUM
Funding agreed upon in the contract and reported in eRapport, but partially under other funding categories			
Own financing	5,852	2,768	8,620
Payment from partner(s) to the host institution	0	0	0
Own financing at partner institutions (in-kind)	0	0	0
The Norwegian Research Council (CoE grant)	7,750	15,500	23,250
External project funds included in the contract	4,650	10,530	15,180
Total funding of the centre as agreed in the contract	**18,252**	**28,798**	**47,050**
Funding of Projects Academically Affiliated with the Centre			
Other project funds from the Norwegian Research Council	11,993	7,887	19,880
International project funds	19,690	15,976	35,666
Public project funds and other public financing	11,993	7,887	19,880
Private project funds and other private financing	27,352	26,278	53,630
Total funding from external projects	**71,028**	**58,028**	**129,056**
Total Funding of Academic Activities	**84,630**	**76,296**	**160,926**

PERSONNEL RESOURCES IN FULL-TIME EQUIVALENTS

27,7	26,4	26,4	15,7	0,4
PROFESSORS, RESEARCHERS, ETC.	PHD CANDIDATES	POSTDOCTORAL FELLOWS	TECHNICAL/ ADMINISTRATIVE STAFF	VISITING RESEARCHERS

The Research Fund of the Kavli Institute for Systems Neuroscience

You can Support ground-breaking neuroscience

Understanding the brain's intricate mechanisms is one of science's greatest challenges. Neuroscience is a field that demands both dedication and innovation in the pursuit of uncovering the brain's complexities. While not everyone can become a neuroscientist, everyone can contribute to vital breakthroughs through the The Research Fund of the Kavli Institute for Systems Neuroscience.

Established by Fred Kavli in 2008, The Research Fund of the Kavli Institute for Systems Neuroscience has been instrumental in supporting the Norwegian Kavli Institute for years. Each year, funds from the brain research fund are transferred to the Kavli Institute, with no restrictions, allowing research to remain innovative and world-class. These contributions come from a diverse range of supporters - foundations, organizations, businesses, families, and individuals - all playing a role in advancing neuroscience.

The Kavli Institute is a beacon of excellence in brain research, and the brain research fund serves as a platform where contributions, big and small, can make a real difference. Thanks to the support of many donors, researchers like May-Britt Moser and Edvard Moser, both Nobel Prize laureates, can continue their pioneering work. Their research has already provided invaluable insights into how the brain works, paving the way for new treatments for various neurological conditions.

Advancing neuroscience is a collective effort. Each of us can contribute, whether through financial support, raising awareness, or championing research initiatives. Together, we can invest in the future of brain research and help create a better world for all.

> ***We are facing serious societal challenges related to brain health. In the world-wide endeavour to find effective treatments and cures for brain diseases, both fundamental and applied research play crucial roles. Investing in brain research is an investment in our future - one with potential for significant returns.***

Members of the board of The Research Fund of the Kavli Institute for Systems Neuroscience: Jan Morten Dyrstad, Hans Jørgen Stang, Anne Lise Ryel, Rune Haglund, Gunnar Kavli Nilsen and Birgit Skarstein.

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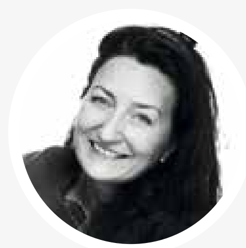

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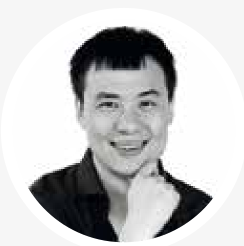

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The 2014 Nobel Laureates 10 years later.
May-Britt Moser, John O'Keefe and Edvard Moser enjoying the evening sun in Trondheim, September 2024

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