



pdn postgraduate

Department of Physiology, Development & Neuroscience

Updated: 8 October 2025

Important note: all applicants for the PhD and MPhil need to identify and make contact with a potential supervisor before submitting their application.

Make contact with the supervisor(s) by email to find out more information about any available projects and whether they will consider your application for a PhD or MPhil. See information in this booklet for details of possible supervisors or check the PDN research themes webpages (<https://www.pdn.cam.ac.uk/research>). Initial enquiries should be made as early as possible. The University funding deadline for PDN applications is **Tuesday 2 December 2025** at 23:59 GMT.

Dr Sumru Bayin

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Co-Supervisor: Professor Emma Rawlins

There is an unmet need for repair following injury in humans, particularly in the brain where endogenous stem cell activity is minimal. An understanding of neural progenitor diversity and flexibility in their fate choices is crucial for understanding how complex organs like the brain are generated or undergo repair. The neonatal mouse cerebellum is a powerful model system to uncover regenerative responses due to its high regenerative potential.

We have previously shown that the cerebellum can recover from the loss of at least two types of neurons via distinct regenerative mechanisms (Wojcinski, 2017; Bayin, 2018; Bayin, 2021). In one case, a subpopulation of the nestin-expressing progenitors (NEPs) that normally generate astroglia undergoes adaptive reprogramming and replenishes the lost neurons. However, the molecular and cellular mechanisms that regulate neonatal cerebellar development and adaptive reprogramming of NEPs upon injury are unknown.

Interestingly, the regenerative potential of the cerebellum decreases once development ends, despite the presence of NEP-like cells in the adult cerebellum that respond to cerebellar injury by increasing their numbers. However, neuron production is blocked. We hypothesise that the lack of regeneration is due to a lack of pro-regenerative developmental signals in the adult brain in addition to epigenetic silencing of stem cell differentiation programs and inhibitory cellular mechanisms as development is completed.

Our lab is interested in answering two overarching questions using interdisciplinary approaches ranging from in vivo mouse genetics, in vitro modelling and stem cell assays, and single cell and other genomics technologies:

- 1) What are the cellular and molecular mechanisms that enable regeneration in the neonates and inhibit in the adult?
- 2) Can we facilitate regeneration in the brain?

Our system allows us to interrogate fundamental stem cell biology questions in a systematic manner and unravel the molecular mechanisms that govern neural stem cells during development, homeostasis and upon injury.

PDN Research Hub: Cell and Developmental Biology, Neuroscience

Postgraduate School of Life Sciences Themes: Molecules and Cells, Neuroscience, Psychology and Behaviour, Reproduction, Development and Lifelong Health (including Physiology)

Additional information:

Dr Riccardo Beltramo

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We study how the brain transforms sensory signals into neural representations of the external world that guide behaviour. Our work focuses on the neuronal circuits underlying visual processing, spatial navigation, and cognitive control, with particular emphasis on the interplay between evolutionarily ancient and modern brain regions. A central question we address is how parallel visual pathways—the superior colliculus and the visual cortex—interact to support adaptive behaviours, such as navigation and defensive responses.

Our lab uses the visual and spatial navigation systems as models, combining electrophysiology, 2-photon imaging, large-scale recordings, and opto/chemogenetics in behaving mice. We are particularly interested in how visual inputs are transformed into spatial maps in the hippocampal formation, and how emotional states influence sensory representations and behavioural responses.

Two PhD projects are currently open to postgraduate applicants:

1) Neural pathways for vision-based spatial navigation.

This project investigates how visual inputs from the superior colliculus and visual cortex contribute to spatial map formation in the hippocampal and parahippocampal regions. Building on our discovery of the postrhinal area (POR) as a cortical target of collicular input, we will study how ancient and modern visual streams integrate to support visually guided navigation.

2) Sensory processing and fear overgeneralization in stress-induced anxiety.

This project examines how stress alters visual sensory circuits involved in discriminating between threatening and safe stimuli. Using chronic imaging and behavioural tasks, we will determine how changes in early sensory encoding contribute to maladaptive fear generalization, a hallmark of anxiety disorders.

Together, these projects aim to reveal how parallel sensory systems interact to shape perception, navigation, and emotional behaviour.

PDN Research Hub: Neuroscience

Postgraduate School of Life Sciences Themes: Neuroscience, Psychology and Behaviour

Additional information:

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My broad aim is to identify how the mammalian brain represents internal nutrient and energy availability and orchestrates behavioural, metabolic and endocrine responses for nutritional homeostasis.

Theme 1: Brain nutrient sensing for amino acid homeostasis:

Half of the amino acids cannot be synthesized by mammalian cells and must be obtained through the diet. A shortage of these essential amino acids rapidly drives protein hunger, yet high circulating levels of amino acids is toxic, leading to metabolic and neurological diseases.

We work under the hypothesis that homeostatic mechanisms regulate peripheral amino acid availability to maintain nutritional balance and ensure survival. Impairments in these pathways contribute to the pathophysiology of obesity and metabolic diseases, but little is known about how this is achieved.

Our goal is to understand how the mammalian brain senses peripheral amino acid availability and produces behavioural and metabolic responses that maintain amino acid homeostasis, and how this regulation is integrated with or might conflict with the maintenance of energy homeostasis. Eventually our goal is to determine if brain protein-sensing pathways represent effective targets for weight-loss interventions and restoring metabolic health.

Theme 2: Nutrient sensing in oligodendrocytes

Oligodendrocytes are myelin-forming cells that ensheath axons to allow rapid saltatory conduction of action potentials. While oligodendrocytes are typically long-lived in a healthy brain, we have found that they rapidly turnover in the median eminence—the brain region through which hypothalamic neurons access blood signals—leading to rapid myelin renewal. This plasticity is regulated by nutritional and metabolic cues. We are actively working on identifying the functional significance of median eminence oligodendrocyte and myelin turnover in neuroendocrine functions and energy and glucose homeostasis.

Theme 3: Targeting brain nutrient sensing for weight loss

Our third goal is to identify the mechanism of action of GLP-1 based weight-loss drugs.

PDN Research Hub: Neuroscience

Postgraduate School of Life Sciences Themes: Metabolic Medicine and Endocrinology, Neuroscience, Psychology and Behaviour

Additional information:

Dr Livia de Hoz

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The de Hoz lab investigates systems neuroscience questions, specifically the role of cortico-subcortical loops in statistical learning. We focus on the auditory system and perform awake/asleep electrophysiology recordings (Neuropixels) and behaviour in mice, while assessing their mental state. We ask questions such as how are noisy sensory inputs recognized and represented in the brain? What is the role of corticofugal projections in setting expectations and interpreting the sensory input? How does the auditory system integrate information over time? How does representation change with mental state (aroused, asleep, groggy)? We are a small, supportive, and dynamic group (www.dehozlab.org) made of a diversity of people united by a passion for science and the brain. This vibrant and interactive department spans systems neuroscience and plasticity questions, and is imbedded in the wider Cambridge neuroscience environment.

The key ingredient is to be passionate about the questions of the lab, to be independent, and a background in systems neuroscience. Ideally you would have some experience with mouse behaviour and/or electrophysiological recordings. Being a pro with Python/MatLab helps.

PDN Research Hub: Neuroscience

Postgraduate School of Life Sciences Themes: Neuroscience, Psychology and Behaviour

Additional information:

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Neuroscience - olfaction - neuronal plasticity - dopamine

PDN Research Hub: Neuroscience

Postgraduate School of Life Sciences Themes: Neuroscience, Psychology and Behaviour

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Decoding the Molecular Basis of Lactation and Early Nutrition to Improve Maternal-Child Health

Lactation is a fundamental characteristic of mammals, providing essential nutrient-rich milk that supports infant growth and development, yet many of its regulatory mechanisms remain unknown. Breastmilk is more than just nutrition: it's a dynamic fluid that shapes infant development, immunity, metabolism, and maternal-infant health.

Our research explores lactation as an integrated system, considering the mother, offspring, and milk as a unified physiological system to uncover how postnatal nutrition is regulated at the molecular level. We focus on developmental biology, epigenetics, and inter-organ communication.

A significant focus of this work is on imprinted genes, which are crucial for embryonic and placental development but remain largely unexplored in relation to mammary gland function. We also explore maternal inter-organ communication involving the mammary gland, both sending and receiving signals, to better understand how lactation is coordinated at the whole-organism level.

We offer several PhD projects that provide the opportunity to work with novel mouse models to investigate how specific imprinted genes influence mammary gland development, regulate lactation, and shape offspring health. Alongside this, students will examine how these genes affect the nutritional and bioactive composition of milk by analysing samples from genetically modified mice. For those interested in translational aspects, we offer a project that extends to human breastmilk, using omics-based approaches to profile gene products and explore their links to maternal and infant wellbeing. These projects offer hands-on training in molecular biology, RNA and protein analysis, and physiological techniques, contributing to a growing, interdisciplinary field with profound evolutionary and societal relevance.

PDN Research Hub: Cell and Developmental Biology, Physiology and Reproduction

Postgraduate School of Life Sciences Themes: Reproduction, Development and Lifelong Health (including Physiology), Women's Health

Additional information:

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My laboratory is interested in the effects of adverse pregnancy on cardiovascular function in the mother, fetus and adult offspring. We work with preclinical animal models including sheep, rats, mice and chicken embryos. We combine experiments in vivo in chronically instrumented preparations, with those at the isolated organ (Langendorff preparations and small vessel myography), cellular (histology and stereology) and molecular (PCR, WB) levels. Current interests are in pregnancy/development affected by chronic hypoxia, obesity and global warming. An example of a project using chicken embryos below:

Title: Hypoxia-Mimetic DMOG Modulates Cardiac Function in Chicken Embryos: A Langendorff Heart Study

Background: DMOG, dimethyloxallylglycine, is a prolyl hydroxylase domain (PHD) inhibitor. By inhibiting PHD enzymes, DMOG stabilises HIF-1 α (hypoxia-inducible factor-1 α), mimicking hypoxic conditions even in normoxia. DMOG is a versatile biochemical tool but has almost exclusively been focused on adult studies, and little is known about whether DMOG can impact on the fetal development and on fetal heart function.

Aims: In this study, we aim to investigate the effects of DMOG during the incubation on the fetal development and on the fetal heart function.

Methods: Chicken embryo model will be used in this study.

Fertilised Bovans Brown eggs will be incubated under normoxic conditions (21% O₂, 45% humidity). Chick embryos will be treated daily with DMOG (10mM in 100 μ L) or vehicle (100 μ L saline) from day 6 to day 10 of incubation. Treatments will be delivered via a 1-mm hole in the eggshell through the air cell and then topically onto the chorioallantoic membrane. The hole in the eggshell will be covered with a small piece of sticky tape at all other times. All treatment procedures will be performed under sterile conditions.

On day 19, following cervical transection and recording of weight of chicken embryo, the heart will be excised, and cardiac function will be determined via a Langendorff preparation. Following measurement of basal function, the heart will be treated with three doses of carbachol, a muscarinic receptor agonist, and three doses isoprenaline, an adrenergic receptor agonist. Chronotropic and inotropic responses of the heart to the doses will be continuously recorded.

In another cohort, frozen heart tissues will be harvested for the analysis of mechanisms.

PDN Research Hub: Physiology and Reproduction

Postgraduate School of Life Sciences Themes: Cardiovascular Science and Medicine, Molecules and Cells, Reproduction, Development and Lifelong Health (including Physiology), Women's Health

Additional information:

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Co-supervisor: Professor Ole Paulsen

Research interests:

- Neuronal circuits of spatial orientation and self-motion perception
- Learning and plasticity in the head direction system
- Age-related decline in the sense of direction

Project 1: Thalamo-Cortical Circuits for Spatial Orientation

Spatial navigation relies on knowing one's orientation relative to the environment and goals. Head direction and angular velocity cells are thought to form the brain's compass, yet their precise role and the circuits through which they shape behaviour remain unclear — partly due to a lack of tasks that reliably isolate directional sense while controlling external cues.

This project uses a novel spatial orientation task in mice, where performance depends on tracking heading with or without external references. We will record from large neuronal populations in the head direction system to assess its contribution under different strategies and dissect thalamocortical circuits using targeted manipulations. PhD students will use cutting-edge techniques, including Neuropixels recordings and opto- and chemogenetics, to explore mechanisms of spatial cognition and goal-directed navigation.

Project 2: Cortical Circuits of Self-motion Perception

Accurate perception of heading and speed is essential for navigation and interpreting the dynamic world. Neurons encoding angular head velocity (AHV) are thought to play a key role in this process. Recent work shows AHV cells in mouse retrosplenial cortex (RSC) integrate vestibular and visual inputs to enhance head motion signalling. However, the specific contributions of inhibitory vs. excitatory RSC neurons to AHV coding and self-motion perception remain unresolved.

This project examines how RSC interneurons and projection cells contribute to AHV coding and behaviour during a self-motion task. Using the mouse model, it combines in vivo two-photon imaging, optogenetics, and a controlled behavioural paradigm. PhD candidates will engage with cutting-edge methods to advance our understanding of self-motion perception and spatial cognition.

PDN Research Hub: Neuroscience

Postgraduate School of Life Sciences Themes: Neuroscience, Psychology and Behaviour

Additional information:

Professor Kathy Niakan

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Our laboratory seeks to determine the molecular mechanisms, timing, and cellular processes involved in human embryonic cell fate specification, implantation, and morphogenesis. Our research program has wide-reaching clinical implications for understanding pregnancy complications, miscarriages, infertility, and developmental disorders. Understanding these processes in human development is also essential to optimize stem cell line generation for regenerative medicine. Functional understanding of human development beyond implantation is foundational knowledge to optimise generation of organoids and human stem cell-based embryo models.

While our laboratory has identified molecular mechanisms regulating initiation of placental progenitor cell differentiation and divergence of the epiblast from yolk sac progenitor cells in human embryos, the mechanisms regulating the establishment and maturation of human embryonic and extraembryonic cells remain largely unknown. The PhD project will use cutting-edge genetic modification and multi-modal -omics and high-resolution imaging analysis to investigate when and how cells of the human embryo become specialized to form the pluripotent epiblast that eventually gives rise to the body or extraembryonic yolk sac or placental progenitor cells.

Research techniques used in the laboratory include: advanced live embryo imaging, preimplantation embryo culture and micromanipulation (human, mouse and cow) proteomics, genome modification (CRISPR base editing), TRIM-Away, genome-wide techniques (i.e. single-cell multi-omics), embryonic and induced pluripotent stem cell derivation.

PDN Research Hub: Cell and Developmental Biology, Physiology and Reproduction

Postgraduate School of Life Sciences Themes: Molecules and Cells, Reproduction, Development and Lifelong Health (including Physiology)

Additional information:

Candidate background

This project would suit a candidate who is curious and passionate to understand the molecular mechanisms that regulate the first cell fate decisions in human embryos. We also seek candidates who have a desire to work in a collaborativ

Professor Caren Norden

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To be established, currently: <https://gimm.pt/lab/caren-norden-lab/>

The NordenLab studies how functional eyes take shape and how our two eyes develop in symmetry. To answer these questions, we use zebrafish and human retinal organoids to uncover the principles of vertebrate retinogenesis from cells to tissue and from optic cup formation to full neuronal lamination.

Optic cup formation is the stage of retinogenesis in which the eye acquires its shape, which is essential for later functionality. We probed how this shape is generated by the interplay of different epithelial rearrangements and their hierarchies. We now aim to understand how the two optic cups in an embryo are generated symmetrically in size and shape, how early asymmetries are corrected, and how the symmetric eye formation can be achieved despite developmental stress.

As the eyes grow, we found that the shape and organisation of the nuclei help maintain neuroepithelial integrity. In new projects, we want to clarify how nuclear arrangements and their movements can influence neuroepithelial dynamics, including their growth and the transition to neuronal differentiation.

Once retinal neurons emerge, they need to move to their final functional location, and we uncovered diverse migration modes, guidance cues, and cell–tissue feedback that guide these movements. We will expand these investigations and ask about general mechanisms and paradigms in the context of human retinal organoids. Furthermore, we want to understand the coordination of neurogenesis within and between eyes and the role of signalling factors and inter-organ communication in ensuring symmetric reproducible neurogenesis outcomes.

All our experimental outlines routinely combine cell and developmental biology approaches with biomechanics, computer science, image analysis and theory. This integrative approach is essential to put findings into a quantitative framework and to generate a deeper understanding of the processes at hand to generalise our discoveries.

PDN Research Hub: Cell and Developmental Biology, Neuroscience

Postgraduate School of Life Sciences Themes: Reproduction, Development and Lifelong Health (including Physiology)

Additional information:

I will be joining the Cambridge University in spring 2026 and be willing and able to accept PhD students in October 2026.

Professor Ole Paulsen

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State-dependent synaptic plasticity and spatial memory encoding in the mouse hippocampus

Synaptic plasticity is a leading cellular model to explain behavioural learning and memory. However, the relationship between the fast timescale of induction of plasticity and the much slower timescales of behavioural learning is not well understood. There is strong experimental evidence that synaptic plasticity is under control by neuromodulators, including acetylcholine and dopamine, which may alter synaptic learning rules both prospectively and retrospectively (Brzosko et al., 2019). This project would test the idea that the neuromodulatory state of the network at different phases of memory encoding could help explain how memories are bound together at different timescales. To this end, the student would use whole-cell patch-clamp recording in brain slices (Fuchsberger et al., 2022), and multi electrode recording, calcium imaging and optogenetics in behaving animals (Jarzebowski et al., 2022), to understand hippocampal encoding of reward-location in a reward-based spatial memory task.

Interested students are encouraged to contact the supervisor for more detailed discussion of potential PhD projects.

Papers:

Brzosko Z, Mierau S and Paulsen O (2019) Neuromodulation of spike timing-dependent plasticity: Past, present, and future. *Neuron* 103: 563–581. DOI: <https://doi.org/10.1016/j.neuron.2019.05.041>.

Fuchsberger T, Jarzebowski P, Clopath C, Brzosko Z, Wang H, Paulsen O (2022) Reactivation of hippocampal neurons enables associative plasticity of temporally discontinuous inputs. *eLife*. DOI: <https://doi.org/10.7554/eLife.81071>.

Jarzebowski P, Hay YA, Grewe BF, Paulsen O (2022) Different encoding of reward location in dorsal and intermediate hippocampus. *Curr Biol* 32: 834–841. DOI: <https://doi.org/10.1016/j.cub.2021.12.024>.

PDN Research Hub: Neuroscience

Postgraduate School of Life Sciences Themes: Neuroscience, Psychology and Behaviour

Additional information:

Dr Eleanor Raffan

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Why are some individuals prone to obesity and yet others stay lean even when they live in a similarly 'obesogenic' environment? Obesity is highly heritable as are related metabolic traits. We study metabolism genetics 'in the round' starting from genetic discovery studies using GWAS and other epidemiological approaches working with 'big data'. We try to ensure we maximise the value of our research by relating our results to both veterinary medicine and human biomedical science.

Capitalising on my background as a vet, we start with animal genetics – dogs, horses and farm animals are excellent models because selective breeding means they show phenotypes of interest, and their genomes are conducive to gene mapping. We follow up genetics with cell studies to understand mechanism, focusing on neuronal development, cell signalling and adipocyte biology, including with transcriptomics. We also study whole body physiology in pet dogs volunteered by their owners.

Projects can be tailored to individual students' interests and skills. Some students in our lab are purely computational but most do a combination of 'wet' and 'dry' lab work or 'dry' lab and epidemiology (recruiting study samples/animals, testing the impact of discovered variants, physiological studies). Currently we have projects available in the fields of:

- Canine obesity and eating behaviour: genetic discovery (GWAS, sequencing) and follow on mechanistic studies (epidemiology, molecular biology)
- Equine obesity and insulin dysregulation: genetic discovery, functional molecular studies.
- Farm animal genomics: integrating publicly available data to reach functional insight into the genomics of fat deposition and food intake.

Please get in touch to find out more, giving plenty of detail about what you like about our lab, our past work, and fields that particularly interest you as well as you explaining your past experiences and existing skills.

PDN Research Hub: Neuroscience, Physiology and Reproduction

Postgraduate School of Life Sciences Themes: Functional and Evolutionary Genomics, Metabolic Medicine and Endocrinology, Neuroscience, Psychology and Behaviour, Reproduction, Development and Lifelong Health (including Physiology)

Additional information:

Professor Emma Rawlins

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The Rawlins lab works on lung stem and progenitor cell biology, combining innovative human organoid models with genetic techniques. Specific research interests include: mechanisms underlying developmental cell fate decisions, similarities and differences between lung development and regeneration, modelling the genetic contribution to lung diseases.

PDN Research Hub: Cell and Developmental Biology

Postgraduate School of Life Sciences Themes: Reproduction, Development and Lifelong Health (including Physiology)

Additional information:

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Have you ever wondered how organs "know" how much they must grow? Our group uses sophisticated genetic models of perturbed limb development to study the local and systemic mechanisms by which growth perturbations are detected and compensated. We use mouse and chicken embryos, coupled with morphometric analyses and state-of-the-art imaging and 'omics' techniques to obtain a more holistic view of intra- and inter-organ cell communication during limb development and regeneration. We are working on 3 main projects:

Cellular and molecular mechanisms of catch-up growth

One powerful approach to study the regulation of organ size is analysing how organs recover a normal growth trajectory after a developmental insult, which is known as catch-up growth. This project will address the mechanisms that trigger the compensatory response upon insult.

Identifying the sizostat (a thermostat for size)

We hypothesise that bone elongation progressively generates a mechanical signal that is transduced into a biochemical one, which in turn affects bone growth. We think that this mechanism works as a thermostat, such that there is an age-dependent threshold for the mechano-transduced signal, and when this signal approaches the threshold, growth is stalled. We are using surgical and genetic tools to monitor and manipulate these mechanical and biochemical signals, with the long-term goal of being able to manipulate individual bone length at will.

Using inter-species chimeras to identify the determinants of limb size

We will generate chimeric animals in which stem cells of species that differ in size from the host give rise to the limb in the context of the host's signals. Detailed anatomical characterisation will assess whether extrinsic signals can modulate limb size and proportions. Gene expression and chromatin accessibility will be compared for the donor limb cells in their endogenous vs. the chimeric context, to uncover the key molecular events underlying this modulation

PDN Research Hub: Cell and Developmental Biology, Physiology and Reproduction

Postgraduate School of Life Sciences Themes: Functional and Evolutionary Genomics, Molecules and Cells, Reproduction, Development and Lifelong Health (including Physiology)

Additional information:

1. Xinli Qu, Ehsan Razmara, [...] Alberto Rosello-Diez. Gli1-expressing stromal cells are highly reparative precursors of long-lived chondroprogenitors in the fetal murine limb. Accepted in Nature Communications. Available through Apollo repository.
 2. Chee Ho H'ng, [...] Alberto Rosello-Diez. Compensatory growth and recovery of cartilage cytoarchitecture after transient cartilage-specific cell death in fetal mouse limbs. Nature communications 2024 Apr 5;15(1):2940. PMID: 38580631. Open Access
 3. Ahmadzadeh E, [...], Joyner AL#, Rosello-Diez A#. A collection of genetic mouse lines and related tools for inducible and reversible intersectional mis-expression. Development. 2020 May 28;147(10):dev186650. doi: 10.1242/dev.186650. PMID: 32366677.
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Dr Keita Tamura

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<https://www.pdn.cam.ac.uk/research/neuroscience/tamura-lab-circuit-physiology-cognition#toc-1>

Co-Supervisor: Hannah Clarke

Why can we easily notice a friend in a crowd and say 'Hello'? Previous neurophysiological studies have revealed how visual inputs are analysed, memorised and recalled, but how the recalled memory is then used to improve perception and make cognitive decisions remains poorly understood. We are investigating brain-wide neuronal circuits signalling object memory for guiding cognitive and perceptual decision makings by developing cutting-edge opto-physiological approaches.

PDN Research Hub: Neuroscience

Postgraduate School of Life Sciences Themes: Neuroscience, Psychology and Behaviour

Additional information:

We aim to develop your full potential!