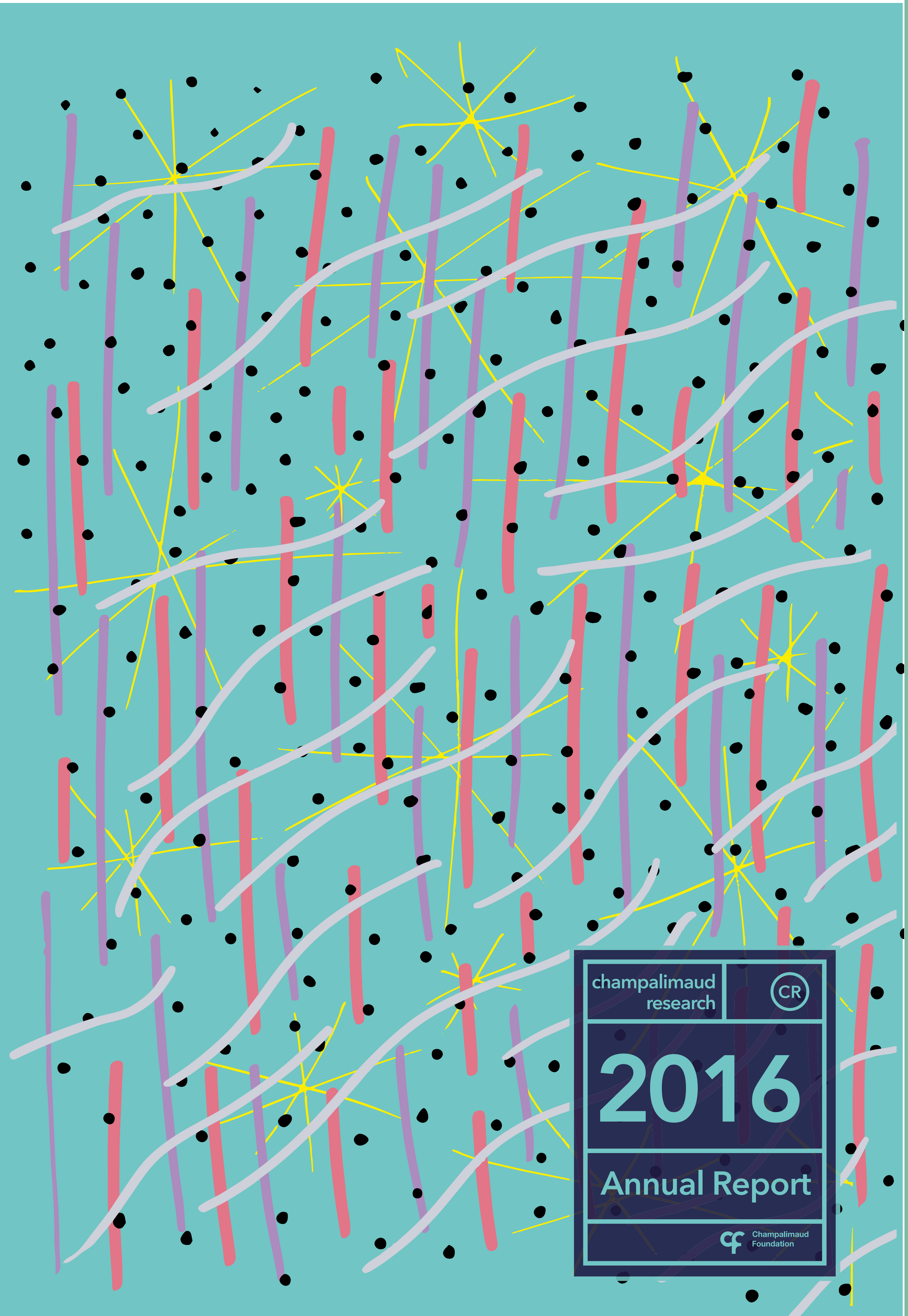

champalimaud research

CR

2016

Annual Report

Champalimaud Foundation

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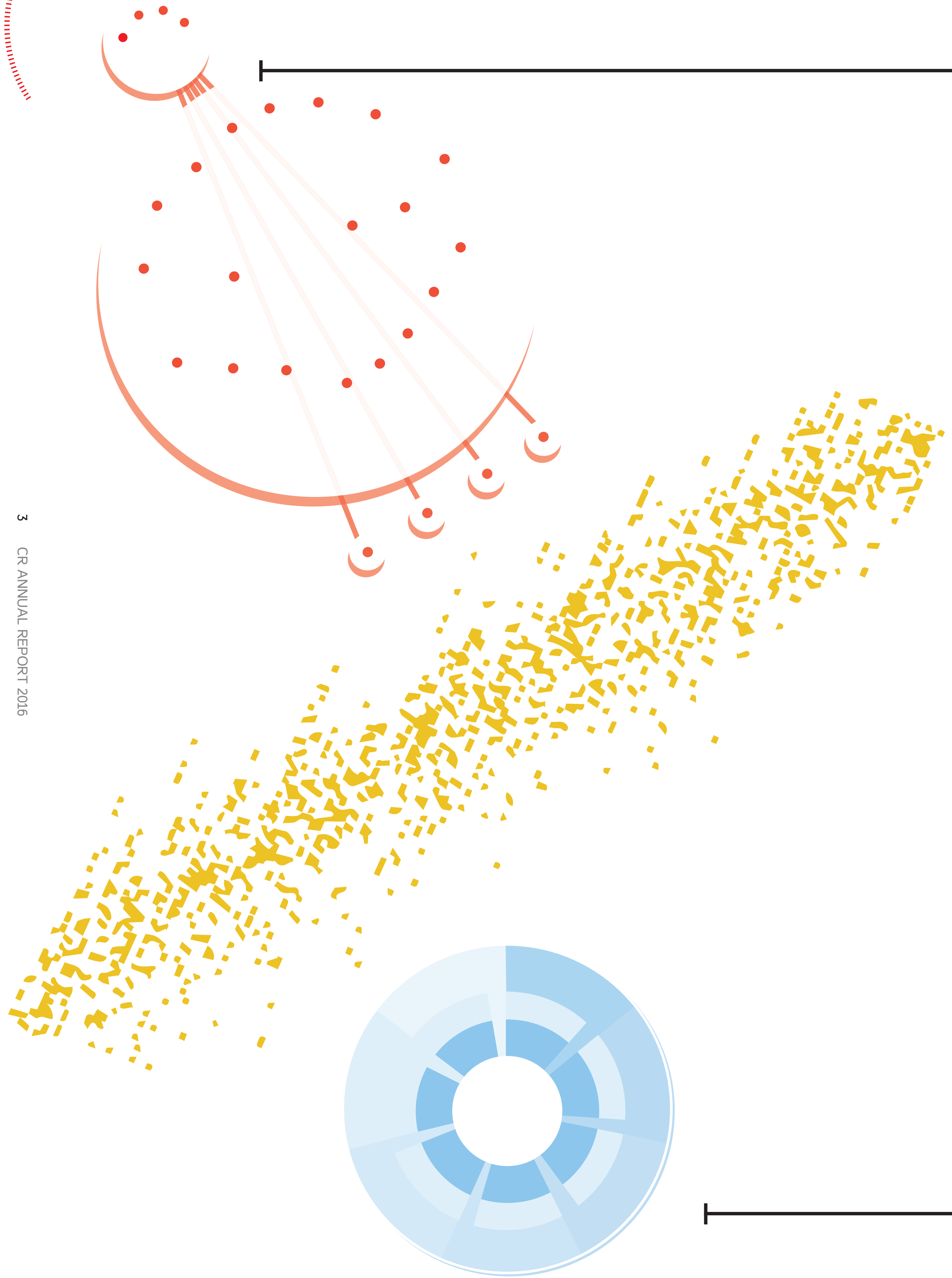


BUILDING FOR THE FUTURE

"CHAMPALIMAUD RESEARCH – AN ENCOMPASSING RESEARCH PROGRAMME SET OUT TO UNDERTAKE TWO GREAT CHALLENGES IN BIOLOGY – THE NEURAL BASIS OF BEHAVIOUR AND THE PHYSIOLOGICAL MECHANISMS OF CANCER."

Through a stretch of a few years, the construction of the Champalimaud Centre for the Unknown has transformed a vacant lot into a prominent Lisbon landmark. Situated on the bank of the river Tagus, the Centre's curved architecture embraces the long-sought ambition to step outward and bring back benefits for humankind. Walking through its halls, visitors may be surprised to find it teeming with clinicians, researchers and patients, all crossing each other's path. Indeed, the Centre was designed to encourage interaction among these individuals, aiming to promote collaborations and progress in the fields of Neuroscience and Cancer. And just as the erection of this monumental structure was accomplished one step at a time, so too the fulfillment of its aim happens in strides.

Champalimaud Research (CR) began with the Champalimaud Neuroscience Programme, now in full swing with 16 established research labs. In 2016, new research labs dedicated to the study of holistic aspects of cancer joined CR, following the official launching of the Biology of Systems and Metastasis (BSM) Programme the year before.

Contrary to the approach many labs take to pursue cancer research, the first three labs of the BSM programme, which will be joined by a fourth in 2017, do not focus on specific tumour types. Instead, they seek to understand how tumour growth and metastasis can happen through the exploitation of healthy systems in the body. Specifically, the lab of Bruno Costa-Silva studies how the exchange of extracellular vesicles, a natural form of communication in the body, can be utilised for tumour expansion. The lab of Eduardo Moreno is dedicated to understanding how the natural mechanisms of cell competition, which are involved in healthy processes that include development and tissue regeneration, can be hijacked for tumour growth. Finally, the lab of Christa Rhiner studies the mechanisms of stem cell activation and specialisation, the understanding of which may shed light on the processes that lead to dysregulated stem cell proliferation resulting in tumour formation.

As of December 2016, the new BSM groups, together with the thriving neuroscience programme, make up an overarching research programme, consisting of 20 research groups and over 300 members. The scientific culture of academic excellence alongside cooperation and support, established by the neuroscience programme, provides a solid foundation from which the new BSM programme is poised to blossom within the next few years.

To support the expanding activities of CR, Celso Matos was appointed as co-director to the CR Direction Team, joining Zachary Mainen and Rui Costa. The Direction Team is responsible for management, assessment and monitoring of CR and works closely with senior scientists and clinical staff to share space and scientific platforms towards successful realisation of the programme's vision of creating fruitful collaborations across fields.

View of the first floor open lab from the library window

THE FOUNDATION

THROUGH SCIENTIFIC BREAKTHROUGHS AND CLINICAL DEVELOPMENTS, THE FOUNDATION IS THERE TO HELP THOSE WHO NEED IT MOST

Leonor Beleza,
President

João Silveira Botelho,
Vice President

António Horta-Osório,
Member of the Board

The Champalimaud Foundation exists as the legacy of Portuguese entrepreneur and industrialist, the late António de Sommer Champalimaud. In accordance with the will of António Champalimaud, Leonor Beleza, former Portuguese Minister of Health, is the President of the Foundation, which was formally created in 2005 under its full title of the Anna de Sommer Champalimaud and Dr. Carlos Montez Champalimaud Foundation, in honour of the benefactor's parents.

The Foundation gives full backing to its researchers who work on the frontline of science and biomedicine. The Foundation's research scientists and doctors use their creativity, experience and talents to find new and innovative ways to approach the many questions of modern neuroscience and oncology.

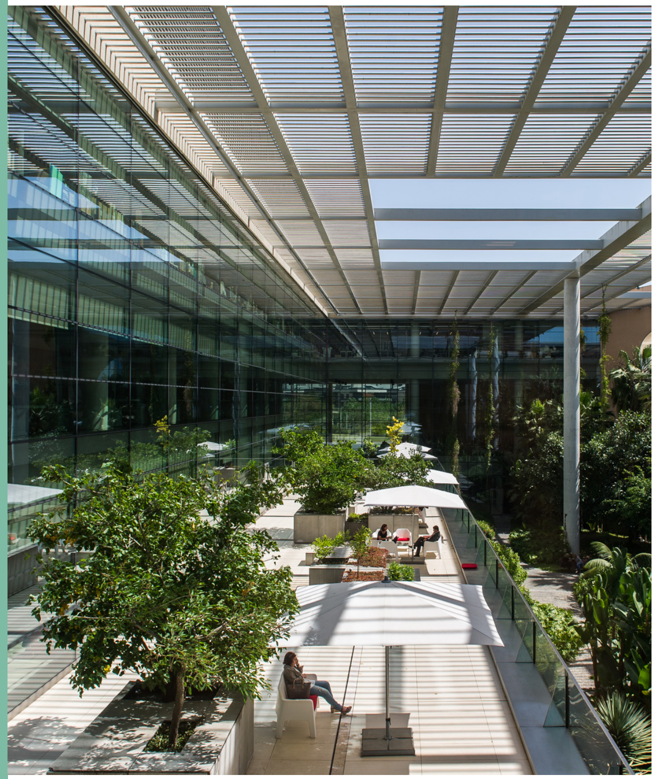
Champalimaud Centre for the Unknown consists of two main branches. Champalimaud Research is made up of 20 groups working on unravelling the neural basis of behaviour and on the Biology of Systems and Metastasis, whereas in the Champalimaud Clinical Centre, healthcare professionals focus on managing and treating diseases. Both branches of the institute work harmoniously and thus illustrate the Foundation's commitment to translational research: to bring the benefits of scientific developments out of the lab and to the patient as soon as possible by developing proximity between Fundamental Science and the Clinic.

Through the António Champalimaud Vision Award, celebrating its tenth edition this year, and the C-TRACER programme, the Champalimaud Foundation is reaching out in the global battle against blindness and vision disorders.

As an institute working at the forefront of both scientific innovation and disease management, The Foundation holds the fundamental belief that the work done at the Champalimaud Centre for the Unknown can benefit humanity. Through scientific breakthroughs and clinical developments, the Foundation is there to help those who need it most.

View of the coffee lounge

The social areas are located at the south tip of the building, overlooking the Tagus river.



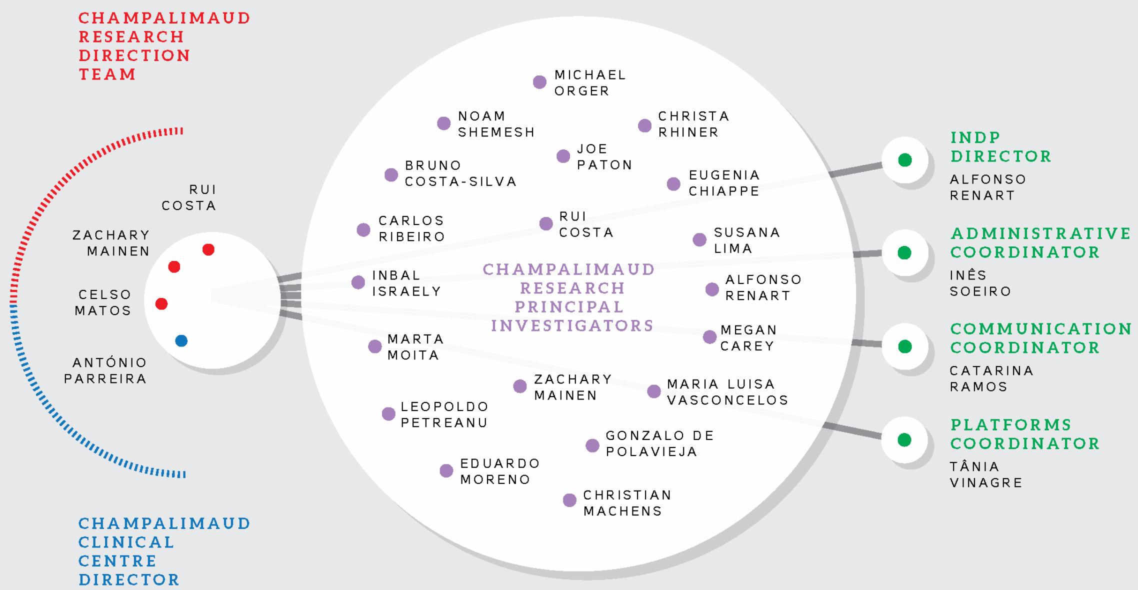
The interior tropical gardens

The Champalimaud Centre has several spaces where staff members and patients can internet in a pleasant atmosphere.

The glass bridge

One of the most striking architectural features of the Champalimaud centre.

Group photo, CR Retreat June, 2016 at Zambujeira do mar, Portugal.



THE SUCCESS
OF THE CR
STEMS
NOT ONLY FROM ITS
HIGH STANDARD
FOR SCIENTIFIC RESEARCH,
BUT ALSO FROM ITS
STRONG SCIENTIFIC CULTURE

SCIENTIFIC ADVISORY BOARD

The Scientific Advisory Board (SAB) of CR is composed of internationally recognised scientists who meet annually to review the progress of CR researchers and programmes. It consists of regular members and additional external members who join on a yearly basis.

REGULAR SAB MEMBERS:

- J. Anthony Movshon, NY University, USA.
- Martin Raff, University College London, UK.

2016 SAB MEMBERS:

- Botond Roska, Friedrich Miescher Institute for Biomedical Research, Switzerland.
- Leslie Vosshall, The Rockefeller University, USA.
- Michael Brecht, Bernstein Center for Computational Neuroscience Berlin, Germany.
- Michael Dickinson, The California Institute of Technology, USA.
- Tom Clandinin, Stanford University, USA.
- Yang Dan, University of California, Berkeley, USA.

Timeline

- Funding
- Publications
- Outreach
- Education
- Events

JANUARY

1st
Begins the funding of an **ERC Advanced Grant**, awarded to Zachary Mainen

6th
How does Serotonin influence sensory processing? Study by the Systems Neuroscience lab

FEBRUARY

1st
Five **FCT scientific research and technological development Projects** were awarded to CR investigators in 2016, each for the sum of 190K euros for a duration of three years

MARCH

1st
The funding of an **ERC Starting Grant**, awarded to Noam Shemesh, begins

APRIL

12th
Can't see the forest for the trees? Try this mathematical steamroller! Study by the **Theoretical Neuroscience** lab.

JUNE

6th-9th
Champalimaud Research **Annual Retreat**

June 27th - July 1st
Summertime scientific activities for high-school students: **"Fruit flies going high-tech: how do fruit flies help us understand the brain?"** funded by Ciência Viva

JULY

1st
Three **EMBO fellowships** awarded to CR postdoctoral researchers

4th
Cortical neural circuitry mapped with unprecedented detail. Study by the Cortical Circuits lab

28th
Breaking the dogma. Study by the Neurobiology of Action lab

AUGUST

7th-27th
CAJAL Course in Computational Neuroscience

SEPTEMBER

21th-24th
5th Champalimaud **Neuroscience Symposium**

OCTOBER

22nd
Hungry for adventure. Study by the Behaviour and Metabolism lab

31st
What is information about movement doing in the visual part of the brain? Study by the Sensorimotor Integration lab

NOVEMBER

26th
"Quantos tempos o cérebro tem" - Workshop as part of the programme of Science and Technology Week

DECEMBER

9th
Controlling subjective time judgement with dopamine. Study by the Learning lab

23rd
INDP Students Graduation Ceremony

Growth & Diversity

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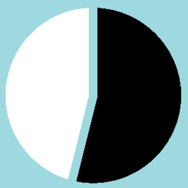
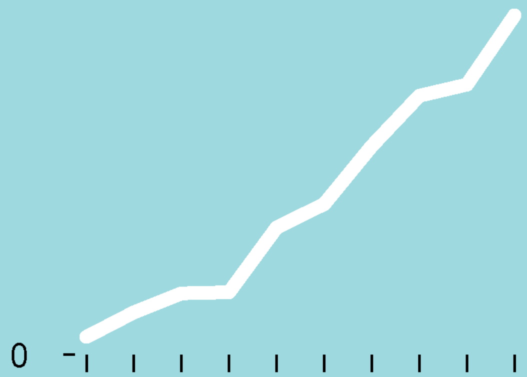
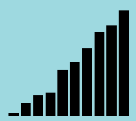
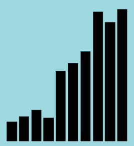
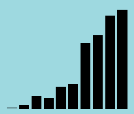
CHAMPALIMAUD RESEARCH MEMBERS

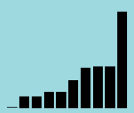


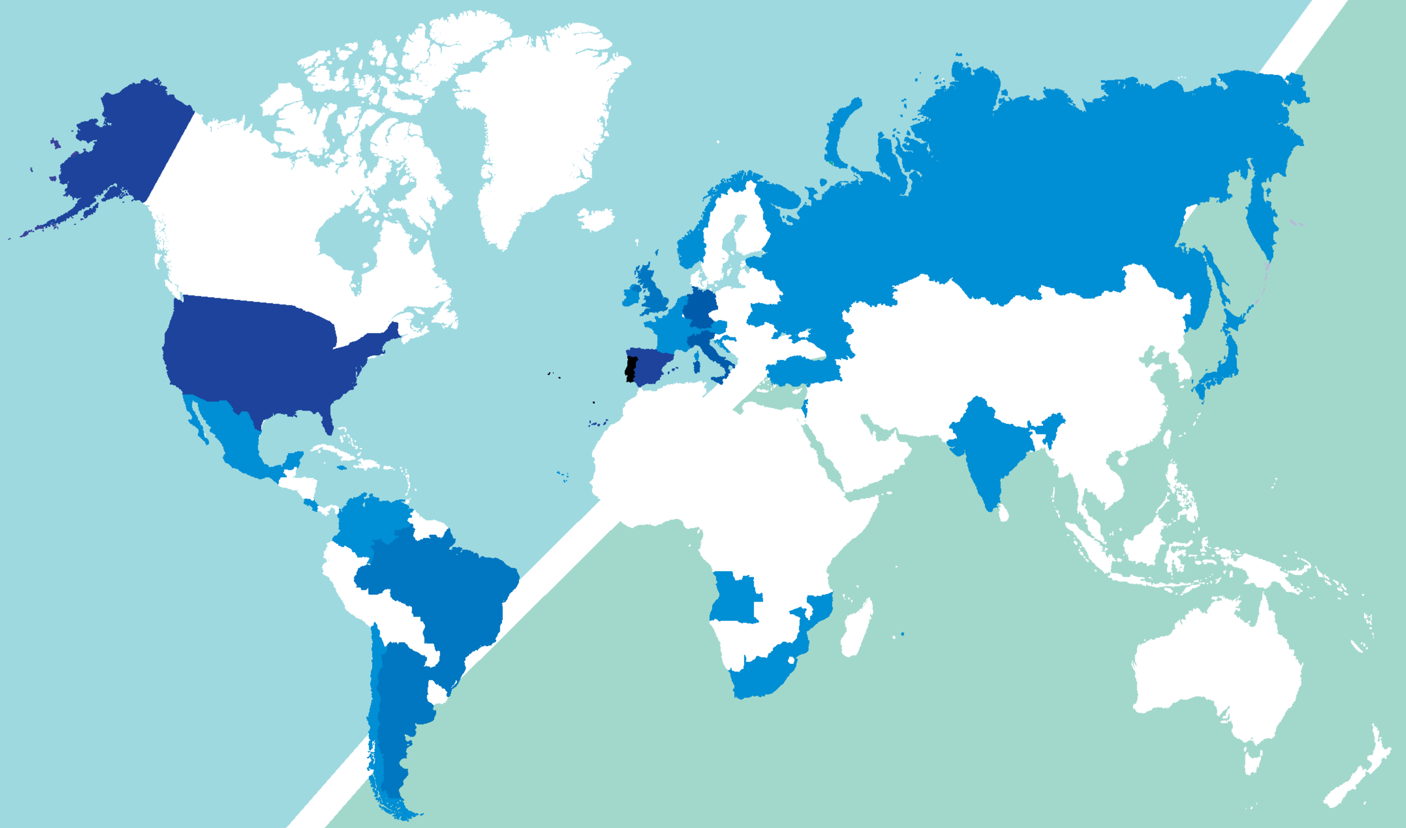












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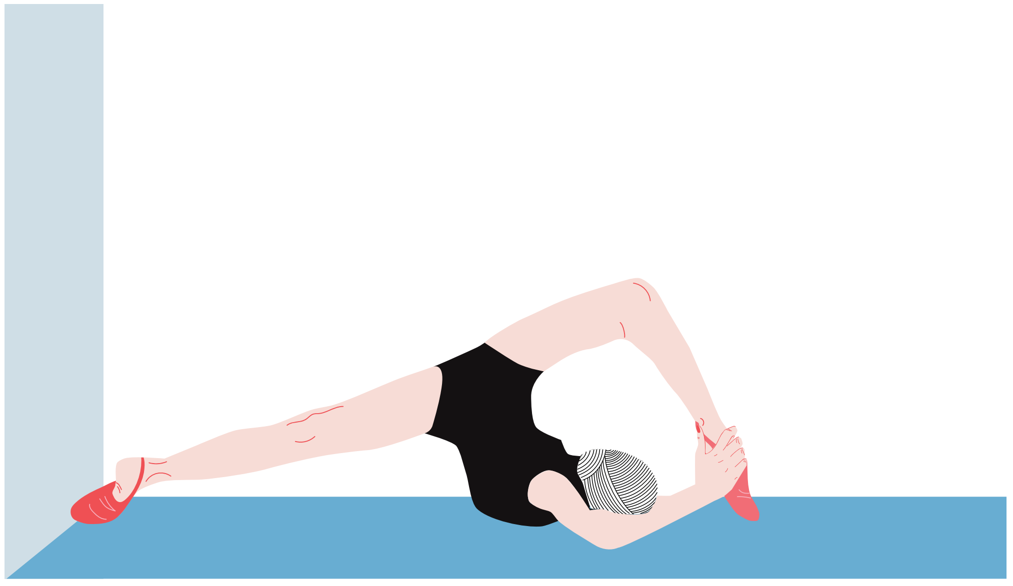
COUNTRIES OF ORIGIN

2	ANGOLA
5	ARGENTINA
2	AUSTRIA
1	BELGIUM
8	BRAZIL
2	CAPE VERDE
1	CHILE
1	COLOMBIA
1	COSTA RICA
1	CROATIA
1	ESTONIA
2	FRANCE
11	GERMANY
2	INDIA
1	IRELAND
3	ISRAEL
12	ITALY
1	JAMAICA
2	JAPAN
1	LESOTHO
1	MAURITIUS
1	MEXICO
1	MOZAMBIQUE
1	NETHERLANDS
3	NORWAY
184	PORTUGAL
3	RUSSIA
18	SPAIN
2	SOUTH AFRICA
2	SWITZERLAND
3	TURKEY
1	VENEZUELA
8	UK
1	UKRAINE
15	USA

POSTCARDS
FROM
THE
UNKNOWN



How does the brain control coordinated movements?

Principal Investigator

MEGAN CAREY

Joined CF in 2010

NEURAL CIRCUITS AND BEHAVIOUR LAB

TAKING IT ONE STEP AT A TIME - INVESTIGATING HOW THE BRAIN CONTROLS COORDINATED MOVEMENT

It's obvious when we think about lead athletes, like gymnasts, that people are capable of remarkable feats of coordination. But in fact, moving different parts of the body relative to each other in a coordinated manner while keeping our bodies balanced and remaining stable is a complex problem that the brain solves all the time. How does the brain control our movements and what happens when the underlying neural circuits malfunction?

Scientific Approach

The Neural Circuits and Behaviour lab studies the cerebellum, a brain area that is critical for coordinated motor control and motor learning. The well-described cerebellar circuit is conserved across species, which enables the researchers to study it in mice, a powerful animal model that offers an array of genetic tools. Using these tools, the researchers are able to measure and manipulate activity in specific populations of neurons in the cerebellum. In some cases, these manipulations mirror neural conditions that exist in humans who suffer damage to the cerebellum through illness or injury. Among the recent advances in the lab was the development of LocoMouse, an open-source tool that allows researchers to observe the fine details of movement with near-millisecond and millimeter resolution. The team developed this tool as the first step in their large-scale project to reveal the neural circuits that generate coordinated walking, for which the lab has received significant support from the European Research Council.

MAIN INTERESTS:
How the brain generates and controls coordinated movement

METHODS:
Quantitative Behavioural Analysis, Electrophysiology, Optogenetics

MODEL / AREA OF FOCUS:
Rodents / Cerebellum

NEURAL CIRCUITS AND BEHAVIOUR LAB

LAB MEMBERS

POSTDOCTORAL RESEARCHERS

1. Dominique Pritchett
2. Hugo Marques
3. João Fayad
4. Dennis Eckmeier

PHD STUDENTS

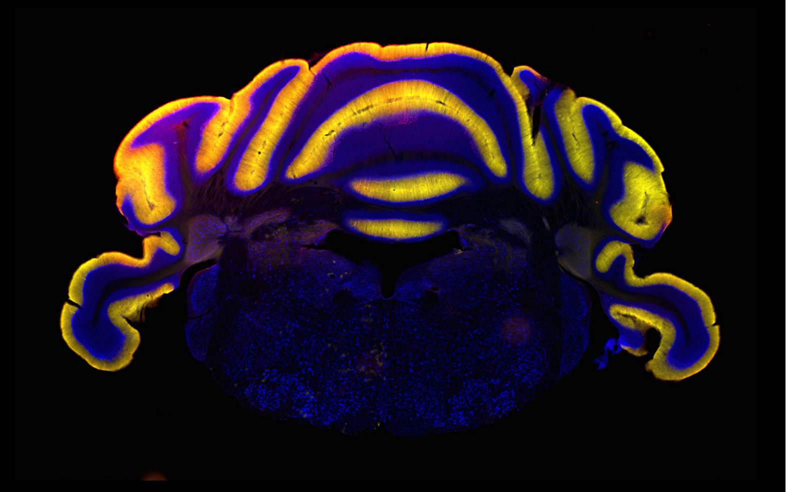
5. Ana Machado
6. Catarina Albergaria
7. Dana Darmohray
8. Jovin Jacobs
9. Tatiana Silva

MASTER'S STUDENTS

10. Gonçalo Figueira

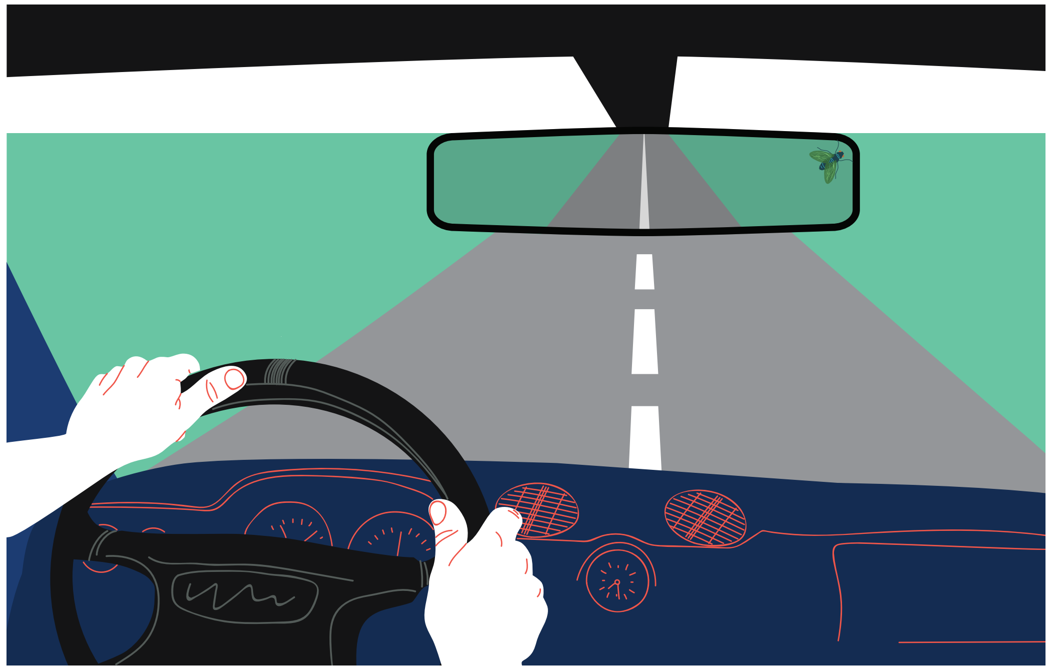
RESEARCH TECHNICIAN

11. Tracy Pritchett



Expressing channelrhodopsin in specific cell types allows for the manipulation of neural activity with laser light.

Fluorescent image of the cerebellum and brainstem of a mouse expressing channelrhodopsin in cerebellar Purkinje cells (yellow). Cell bodies are labeled in blue, cabindin staining is in red.



How does the brain know that we are moving and not the landscape?

Principal Investigator
EUGENIA CHIAPPE
Joined CF in 2012

SENSORIMOTOR INTEGRATION LAB

MOTION SELFIES - HOW THE BRAIN CAPTURES THE BODY IN ACTION

Think about how difficult brushing your teeth might be if you didn't have a sense of where your arm is relative to your mouth. You might find the toothbrush in your eye, or up inside your nose... To ensure the success of the most trivial, or the most elaborate action, the brain has to simultaneously monitor the position of all body parts, their speed of movement and the posture of the individual. To accomplish this, it combines information about its internal movement plan with information from sensory feedback caused by the ongoing movement. Both vision and proprioception, the sense that informs the brain about the tension and position of each joint of the body, monitor how well the planned movement is being executed. Together, all these inputs are used to inform the brain about the movements of the individual and fine-tune them on a rapid, "on the fly" timescale. How is this internal representation of self-movement generated across neural networks in the brain?

Scientific Approach

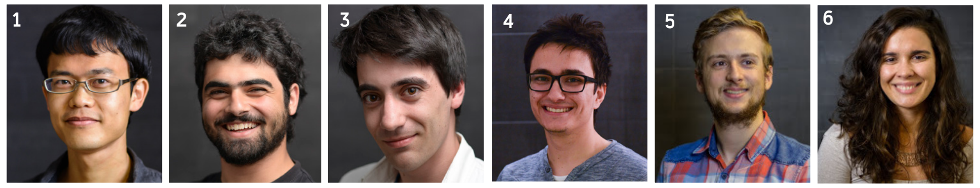
To address this fundamental question, the Sensorimotor Integration lab focuses on transformations of visual information into motor action in the fruit fly *Drosophila melanogaster*. Experiments in the lab combine quantitative analysis of behaviour with simultaneous monitoring and manipulation of neural activity in genetically identified populations of neurons. In this manner, the team can artificially silence or activate neurons of interest and observe what happens to the patterns of activity of other neurons within the network, as well as to the behaviour of the fly. In addition, to directly probe what features of the visual world the brain uses to control the behaviour of the fly, the lab also uses carefully constructed virtual reality environments. Ongoing work in the lab has revealed that a group of visual interneurons, previously thought to be purely sensory, receives quantitative information about the fly's speed and direction of walking. These results show that when the animal is engaged in locomotion, motor-related signals are forecasted with exquisite detail and specificity to sensory regions. This information may be used to distinguish self-generated from nonself-generated sensory information, or in producing an accurate internal representation of self-movement.

MAIN INTERESTS:
The computational principles that govern integration of motor actions with sensory information

METHODS:
Electrophysiology, Behaviour, Optogenetics, Virtual Reality

MODEL / AREA OF FOCUS:
Fruit Fly / Sensory, Motor and Premotor Brain Areas

SENSORIMOTOR INTEGRATION LAB



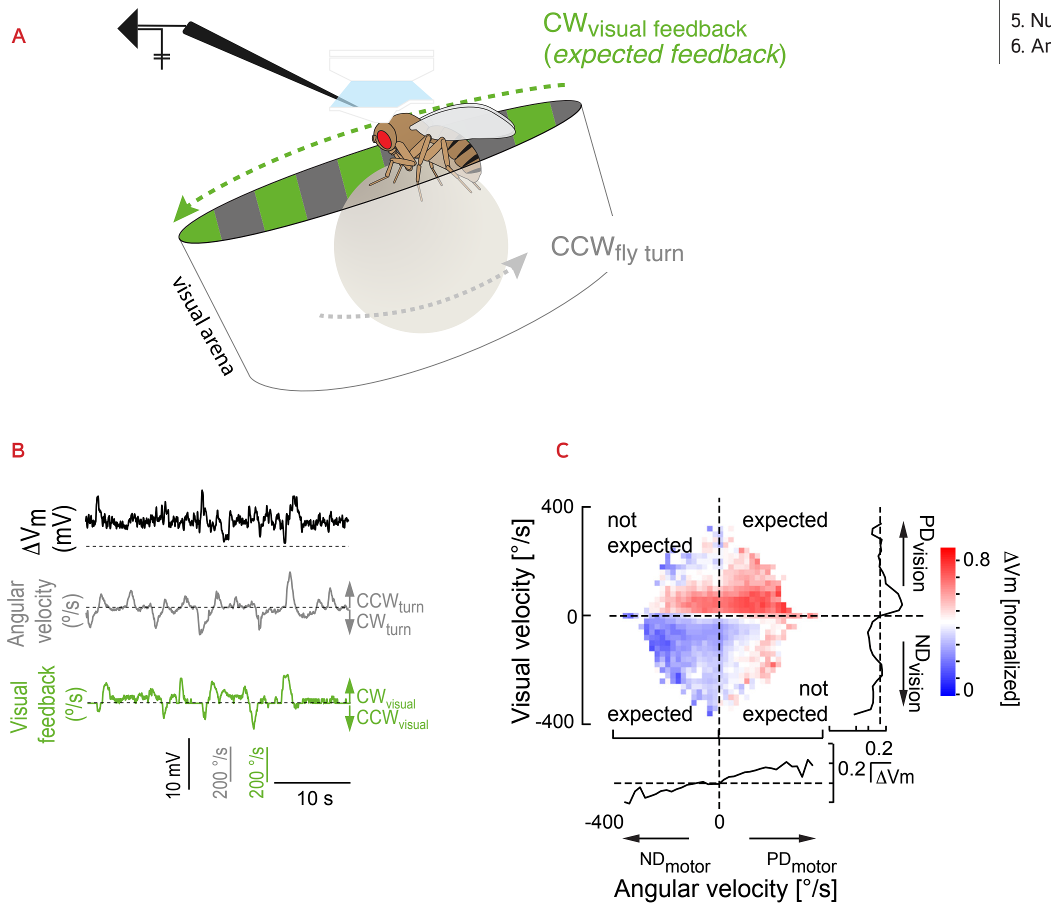
LAB MEMBERS

POSTDOCTORAL RESEARCHERS
1. Terufumi Fujiwara

PHD STUDENTS
2. Mert Erginkaya
3. Tomás Cruz

MASTER'S STUDENTS
4. André Marques

RESEARCH TECHNICIANS
5. Nuno Rito
6. Anabel Rodriguez Simões

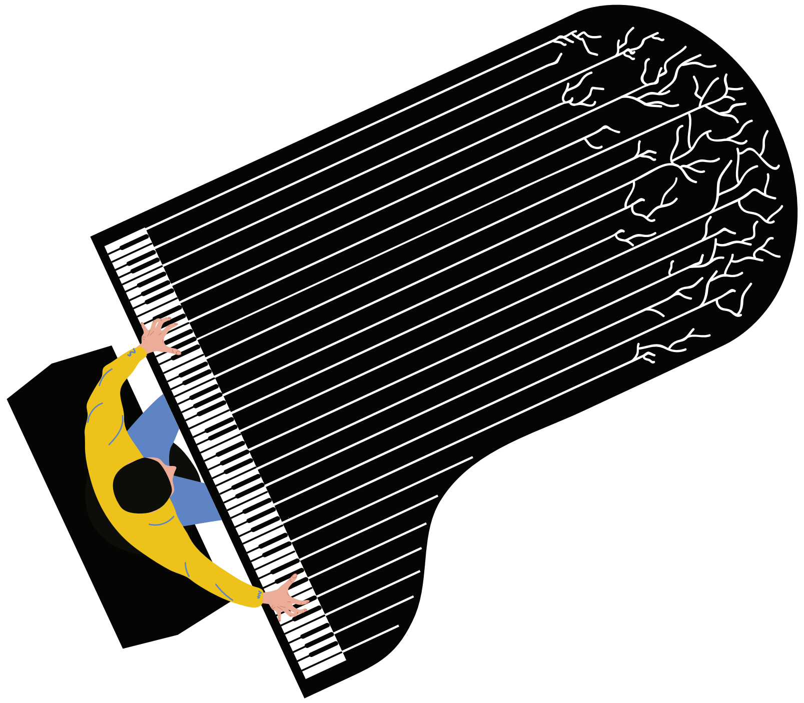


Integration of visual and non-visual information in optic-flow sensitive neurons.

A) Simultaneous recordings of the fly's walking movements and of optic-flow sensitive neurons while the fly is stimulated with rotional optic flow-like stimuli. Under natural conditions, a turn of the fly to the left will generate visual motion signals to the right (expected visual feedback).

B) Example of a trial where the visual stimulus was decoupled from the walking activity of the fly (replay condition), i.e., the visual stimuli could be both expected and not expected from the fly's behaviour.

C) Velocity sensitivity of optic-flow sensitive neurons in replay conditions. Neural response amplitude under expected vs. not expected visual feedback shows that neurons are more sensitive when visual stimuli is expected from the walking behaviour of the fly.



What happens in the brain when learning a complex task?

Principal Investigator

RUI COSTA

Joined CF in 2008

NEUROBIOLOGY OF ACTION LAB

READY, SET, ACTION!

Our daily lives can be viewed as a series of actions. Some of them, like driving home, are well-rehearsed and habitual, while others, such as learning how to play a new sport, require goal-directed attention. We know intuitively that these different types of actions require different mental resources. For instance, while you could easily sing along with the radio while driving home, you probably wouldn't manage it quite as well on your first day on the tennis court. This fact may seem trivial, but it raises many different questions as to how these differences are reflected on the level of the brain. Are habitual and goal-directed actions controlled by the same or by different neural processes? How does the brain learn to perform new actions? What happens if the neural circuits that underlie action initiation or termination malfunction?

Scientific Approach

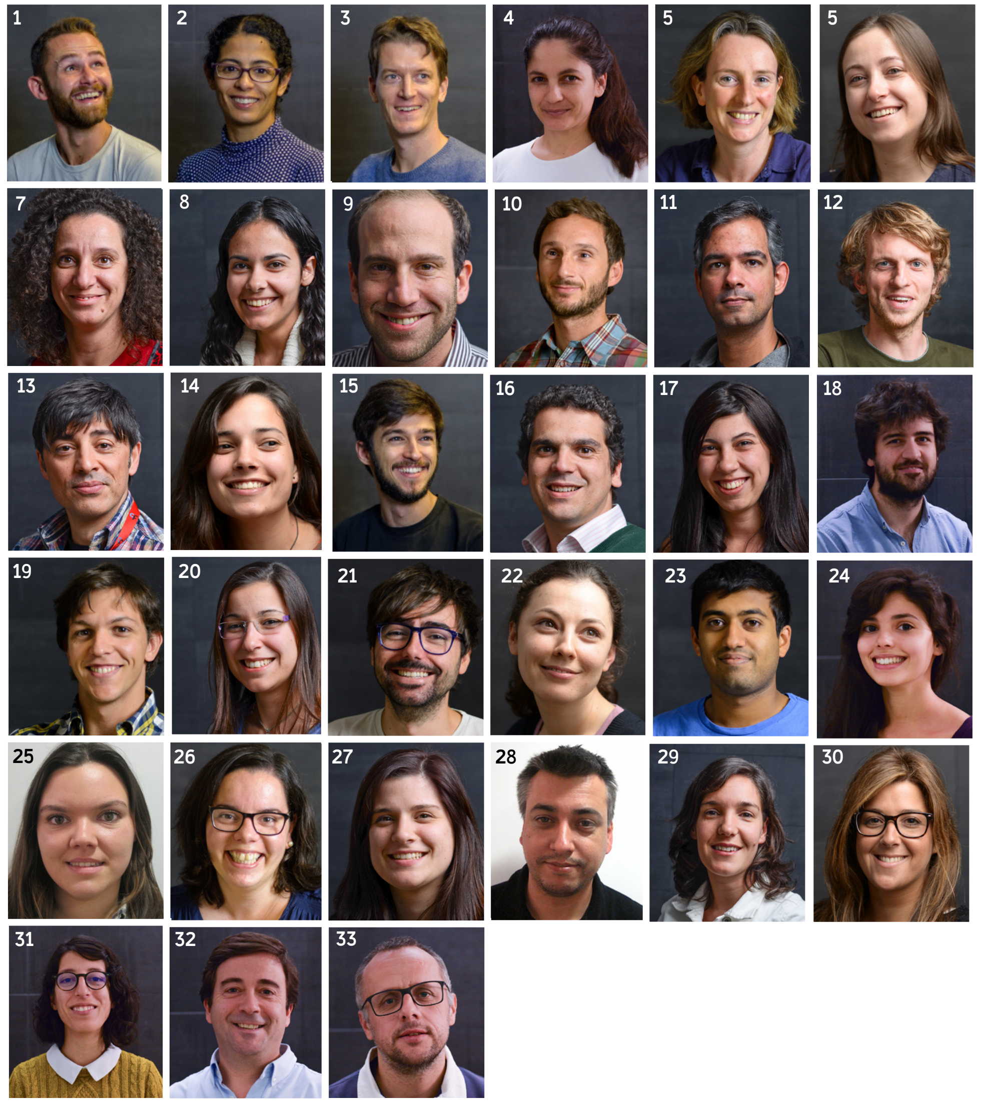
To find the answers to these questions, the Neurobiology of Action lab uses a cross-level approach, from molecules to neural circuits. Specifically, the lab focuses on the interaction of the basal ganglia, a brain region known to be involved in motor learning and in the control of movement, with areas in the cortex that are important in motor planning and decision-making. These brain areas are also affected in neural disorders such as Parkinson's disease, Huntington's disease and obsessive-compulsive disorder. Work from the lab has generated various findings in the field, including the description of a process called "chunking" in the basal ganglia in which single motor elements are joined, or "chunked" together to create a single entity. Through this process, for example, the neural representations of single syllables may become representations of entire words. In addition, the team has identified that mastering challenging motor tasks depends on the brain's ability to select the most important movement elements. Finally, most recently, the lab has produced groundbreaking observations challenging some of the previously held perceptions regarding the role of subcircuits in the basal ganglia.

MAIN INTERESTS:
How the brain generates and selects actions

METHODS:
Optogenetics, Electrophysiology, Behaviour

MODEL / AREA OF FOCUS:
Rodents, Humans / Basal Ganglia, Orbitofrontal Cortex

NEUROBIOLOGY OF ACTION LAB



LAB MEMBERS

POSTDOCTORAL RESEARCHERS

1. Aaron Koralek
2. Ana Cruz
3. Andreas Klaus
4. Catarina Carvalho
5. Catherine French
6. Cátia Feliciano
7. Cristina Afonso
8. Gabriela Martins
9. Nicolas Morgenstern
10. Paolo Botta
11. Rodrigo Oliveira
12. Thomas Akam
13. Vitor Paixão

PHD STUDENTS

14. Inês Vaz da Cunha
15. Ivo Marcelo
16. Joaquim Alves da Silva
17. Mafalda Vicente
18. Marcelo Sousa
19. Nuno Loureiro
20. Patricia Rachinas-Lopes
21. Pedro Ferreira
22. Sevinç Mutlu
23. Vivek Athalye

MASTER'S STUDENTS

24. Ana Rita Afonso
25. Sandra Gomes

RESEARCH TECHNICIANS

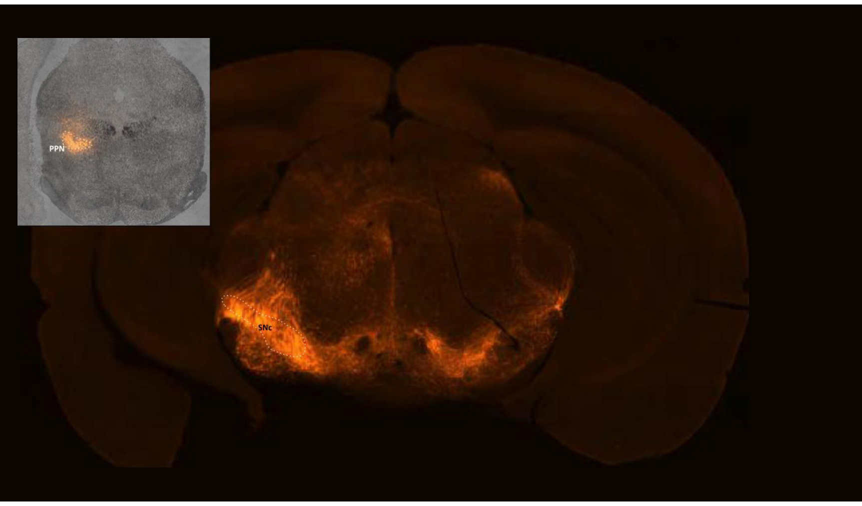
26. Ana Vaz
27. Mariana Correia
28. Hélio Rodrigues

CLINICAL RESEARCH FELLOWS

29. Ana Fernandes
30. Ana Catarina Castro
31. Marta Camacho

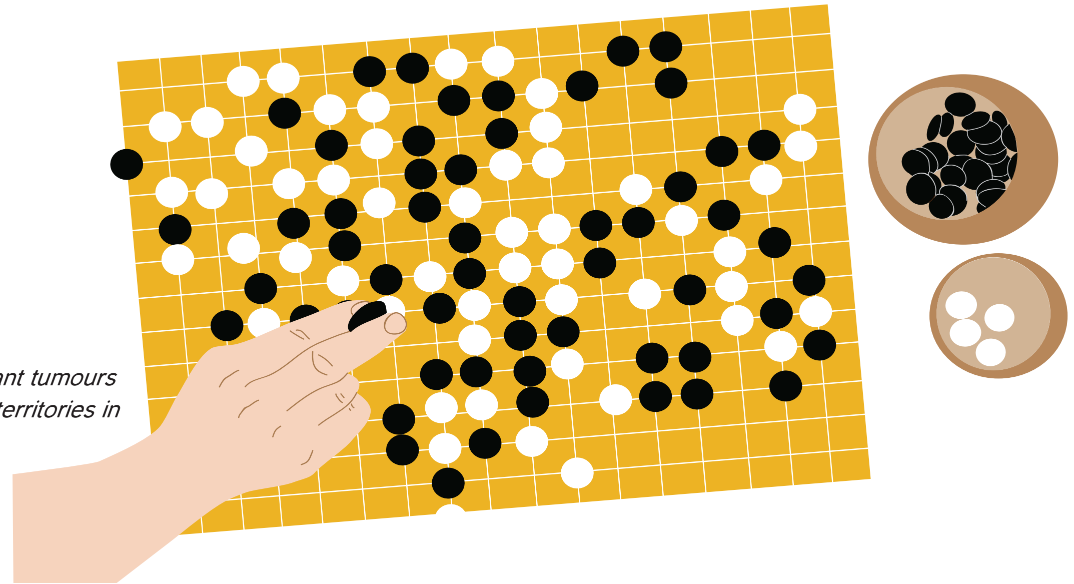
PROGRAMMER VISITING FELLOWS

32. Helge Gudmundsen
33. Ricardo Matias



PPN glutamatergic neurons project to Substantia Nigra Pars compacta

vGluT2-Cre mice were stereotactically injected with AAV2-EF1a-DIO-TdTomato in PPN to express tdTomato in glutamatergic projections. Extensive glutamatergic projections to Substantia nigra can be observed both ipsilaterally and contralaterally. photo credit: Ana Cruz



How do malignant tumours expand to new territories in the body?

Principal Investigator

BRUNO COSTA-SILVA

Joined CF in 2016

SYSTEMS ONCOLOGY LAB

CROSSING THE LINES - HOW CANCER HIJACKS THE BODY'S COMMUNICATION SYSTEMS

Cancerous tumours do not grow in a vacuum. To develop and expand they depend on the active support of normal healthy tissue. Despite that, most current cancer research focuses on specific cancer types instead of observing the problem on a whole-organism systemic level. An innovative approach aims to gain a novel perspective on cancer by studying the mechanisms by which tumour cells utilise the body's innate forms of communication to recruit non-tumour cells to support tumour growth and metastasis.

Scientific Approach

The general interest of the Systems Oncology lab is to understand how crosstalk between tumour cells and non-tumour cells supports oncologic disease. Specifically, the lab studies how the exchange of extracellular vesicles, a natural form of communication in the body, can be utilised by cancerous tumours for growth and metastasis. Recent results from the team have shown not only that these vesicles are different in cancer patients, but also that they can activate healthy cells at remote locations to support tumours. Following these results, the lab currently focuses on developing animal models of tumour initiation, progression and metastasis, in combination with characterisation of extracellular vesicles isolated from tumour cell lineages and oncologic patients with diverse clinical profiles. By using this approach, the lab aims to gain mechanistic understanding of this form of communication with the end goal of developing tools for early detection, follow-up and treatment of cancer.

MAIN INTERESTS:
How the exchange of extracellular vesicles can be utilised by cancerous tumours for growth and metastasis

METHODS:
Flow Cytometry, Cell Cultures, Animal Models Of Cancer

MODEL / AREA OF FOCUS:
Zebrafish, Mice, Human / Tumours, Tumour-associated Cells

SYSTEMS ONCOLOGY LAB

LAB MEMBERS

POSTDOCTORAL RESEARCHERS

1. Sergio Caja Galán

PHD STUDENTS

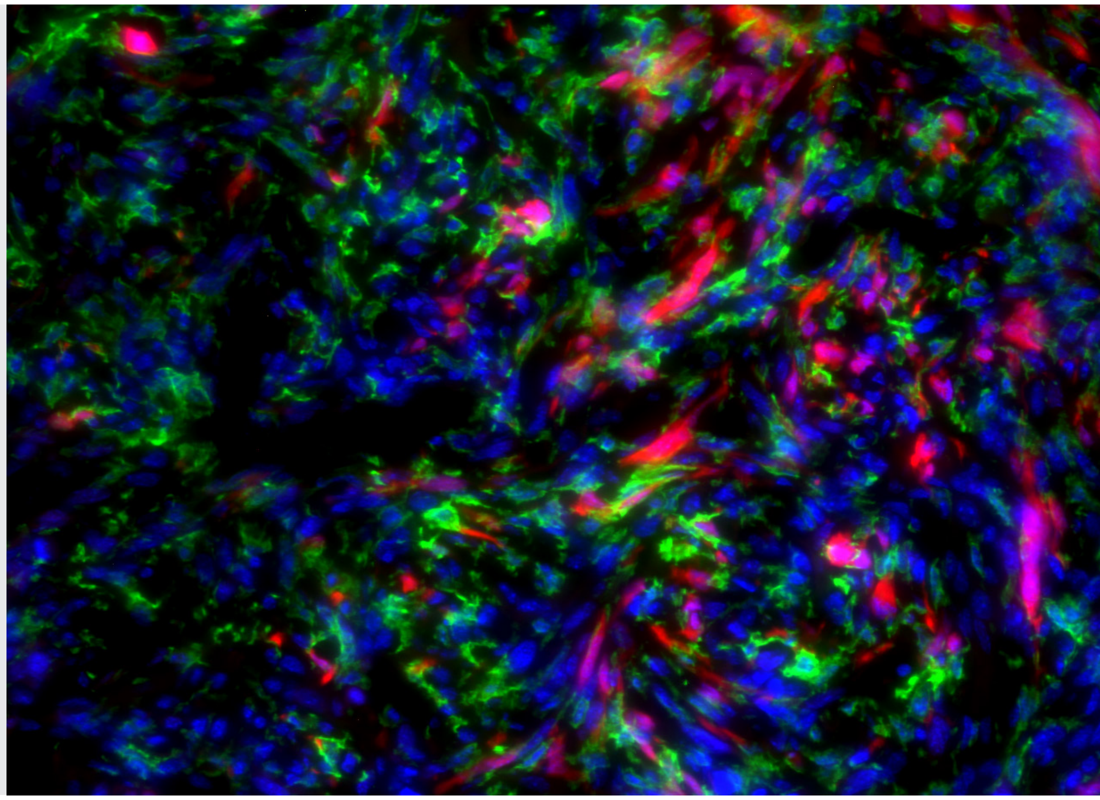
2. Bruna Ferreira
3. Joana Maia
4. Inês Ferreira
5. Nuno Couto

MASTER'S STUDENT

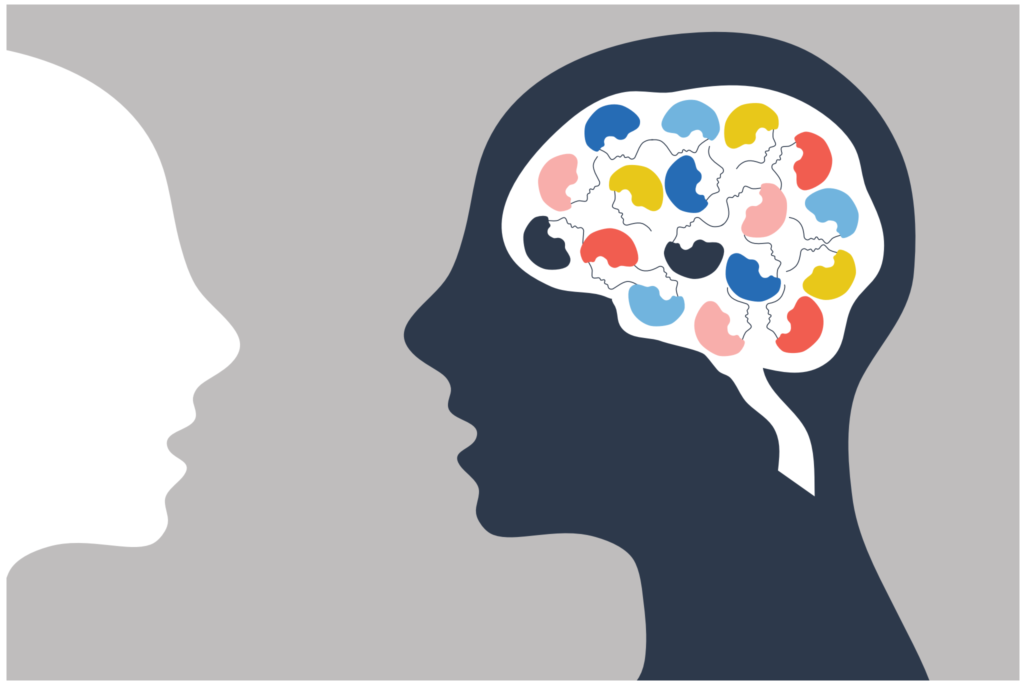
6. Mafalda Ferreira

RESEARCH ASSISTANT

7. Maria Carolina Strano Moraes



Tumour-associated cells (green) adjacent to **tumour cells** (red) at a metastatic site



What are the properties that control the emergence of collective behaviour?

Principal Investigator

GONZALO DE POLAVIEJA

Joined CF in 2014

COLLECTIVE BEHAVIOUR LAB

SOCIETY: A WHOLE GREATER THAN THE SUM OF ITS PARTS?

Information processing can be achieved through the interaction of units in collectives. Examples of successful interactions are fish schools escaping predators, thinking by brains and learning in artificial networks. Though clearly central to the functioning of many systems, the properties that control the emergence of collective behaviour are still largely unknown. Applied mathematics and machine learning are essential tools to discover the rules of interaction and their influence in different collective systems. How can these rules explain the emergence of group patterns ranging from the captivating swirling of shoals of fish, or flocks of birds, to politics, or economics?

Scientific Approach

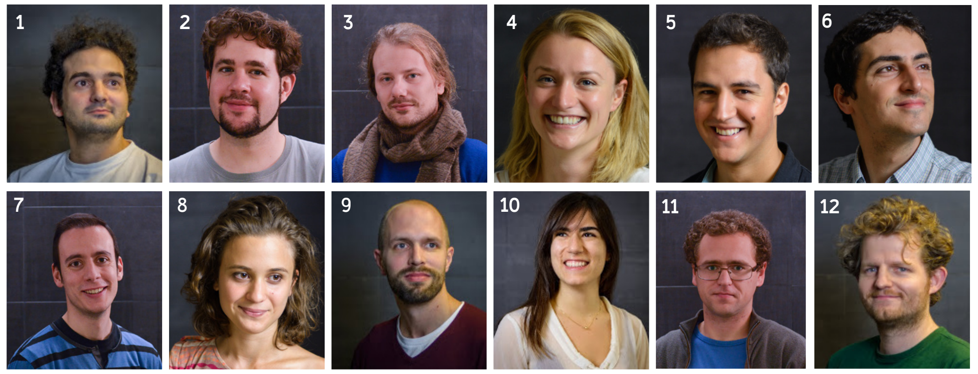
The Collective Behaviour lab, a multidisciplinary team that includes mathematicians, physicists and biologists, applies computational, behavioural, molecular, imaging and virtual reality approaches to studying these questions. The team implements this diverse set of tools in zebrafish and humans. In this 'way, insights gained in zebrafish are used by the researchers to design models which they test and extend to human experiments. In addition, the lab also works on the development of tools and techniques aimed at obtaining richer datasets essential to the formulation of better models of collective behaviour. The lab's recent advances include the development of a mathematical model of decision-making in groups that works well across species, from ants to humans. With this model, the researchers were able to demonstrate how individuals faced with ambiguous sensory information, such as a disguised predator, can use social cues to improve the accuracy of their decisions. The team has also been able to use these models to propose new ways to tap into collective intelligence.

MAIN INTERESTS:
Formulating the rules that explain the interaction between the group and the individual

METHODS:
Behaviour, Neurobiology, Molecular Biology, Mathematical Modelling

MODEL /AREA OF FOCUS:
Zebrafish, Humans / Whole Brain

COLLECTIVE BEHAVIOUR LAB



LAB MEMBERS

POSTDOCTORAL RESEARCHERS

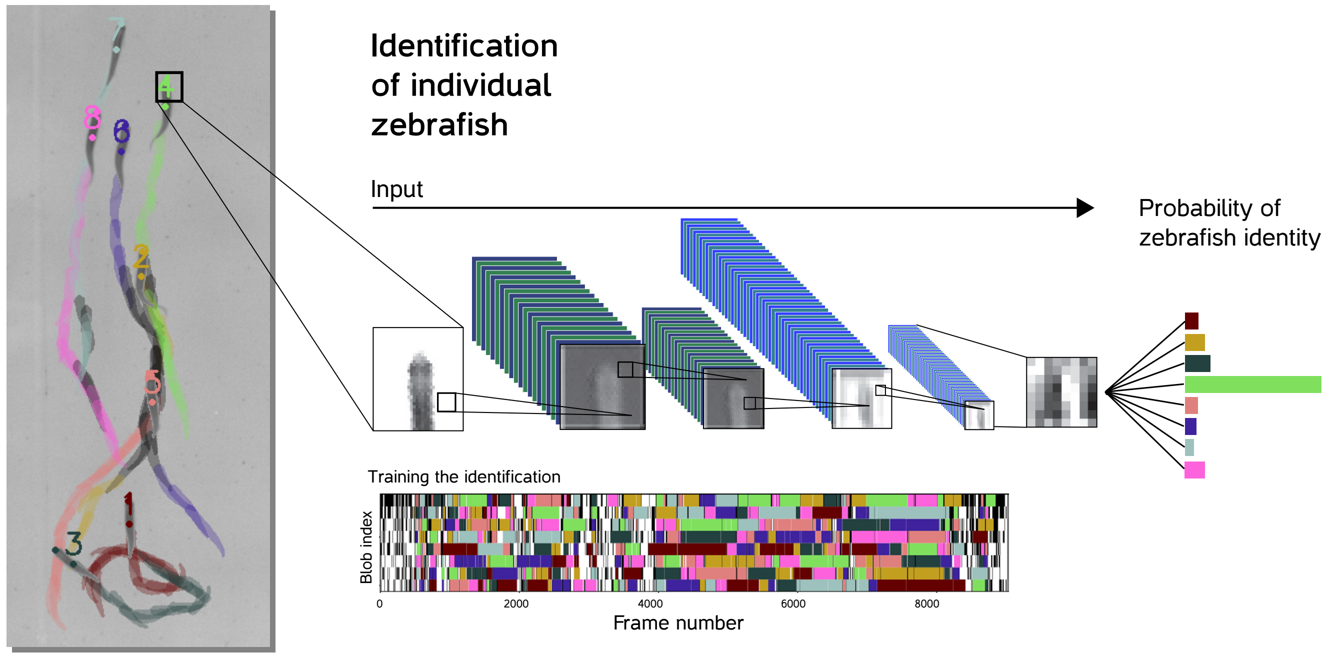
1. Angel Roman
2. Francisco J. Heras
3. Mattia Bergomi

PHD STUDENTS

4. Antonia Groneberg
5. Francisco Romero
6. Gabriel Madirolas
7. Júlian Vicente
8. Marta Iglesias
9. Robert Hinz
10. Victoria Brugada

RESEARCH TECHNICIANS

11. Andres Laan
12. Ivar Clemens



Zebrafish moving in groups

Machine learning methods (deep learning network) are used to identify individuals in groups to test new theories of collective motion and collective decision-making.

How are memories physically stored in the brain?

Principal Investigator

INBAL ISRAELY

Joined CF in 2009

NEURONAL STRUCTURE AND FUNCTION LAB

THE SHAPE OF MEMORIES

From the moment we are born, our experiences continuously change our knowledge and abilities. These changes include both acquiring new memories and skills and forgetting others. It is widely believed that these changes are reflected in the potency of the connections between neurons. What changes in the physical connections between neurons take place in order to allow us to processes information, as well as to retain it for very long times, perhaps even over our entire lifetime? Can these changes be visualised as physical, structural modifications in the neurons themselves? We know that when information is transmitted between neurons, some of this activity leads to changes in the small protrusions at which they contact one another, called spines, but we do not yet understand how their physical organisation and reorganisation supports learning and memory. How do the various components of a memory or episode become physically integrated? Does the physical location of synapses on spines within neuronal branches support complex processing and allow us to learn and store many unique components? We know relatively little about how physical changes in connectivity underlie the fundamental processes of cognitive function.

Scientific Approach

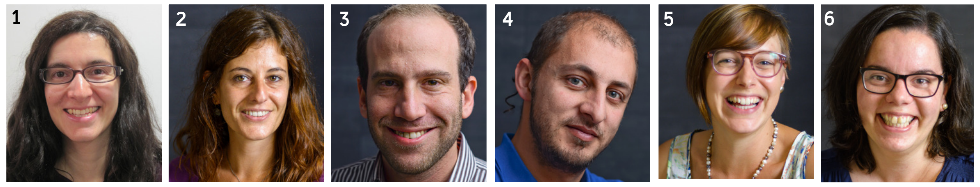
In the Neuronal Structure and Function lab the investigators use optical, genetic, electrophysiological and computational techniques to study experience-induced structural changes in neuronal spines. Spines are finger-like projections on which synapses, the points of connection between excitatory neurons, are located, and so it is there that information is stored, or lost. The group focuses on the neuronal spines of the hippocampus, a brain region that is known to be involved in memory formation, but they also investigate structural plasticity across different types of neurons in order to deduce a common mechanism for information storage in the brain. Using highly focused laser light, they are able to precisely select and stimulate individual contacts of a mouse neuron. This allows them to follow how different patterns of activity can result in either the growth or shrinkage of spines, and also to uncover how spines influence each other when several are active at the same time. In addition, since abnormal spine shape is observed in several neurodevelopmental disorders in humans, including autism spectrum disorders, the lab also studies neurons from animal models in order to better understand the connection between structure and cognitive function.

MAIN INTERESTS:
How activity between neurons leads to changes both in the function and structure of synapses

METHODS:
Imaging, Optogenetics, Glutamate Uncaging, Synaptic Plasticity, Computation

MODEL /AREA OF FOCUS:
Rodents / Hippocampus

NEURONAL STRUCTURE AND FUNCTION LAB



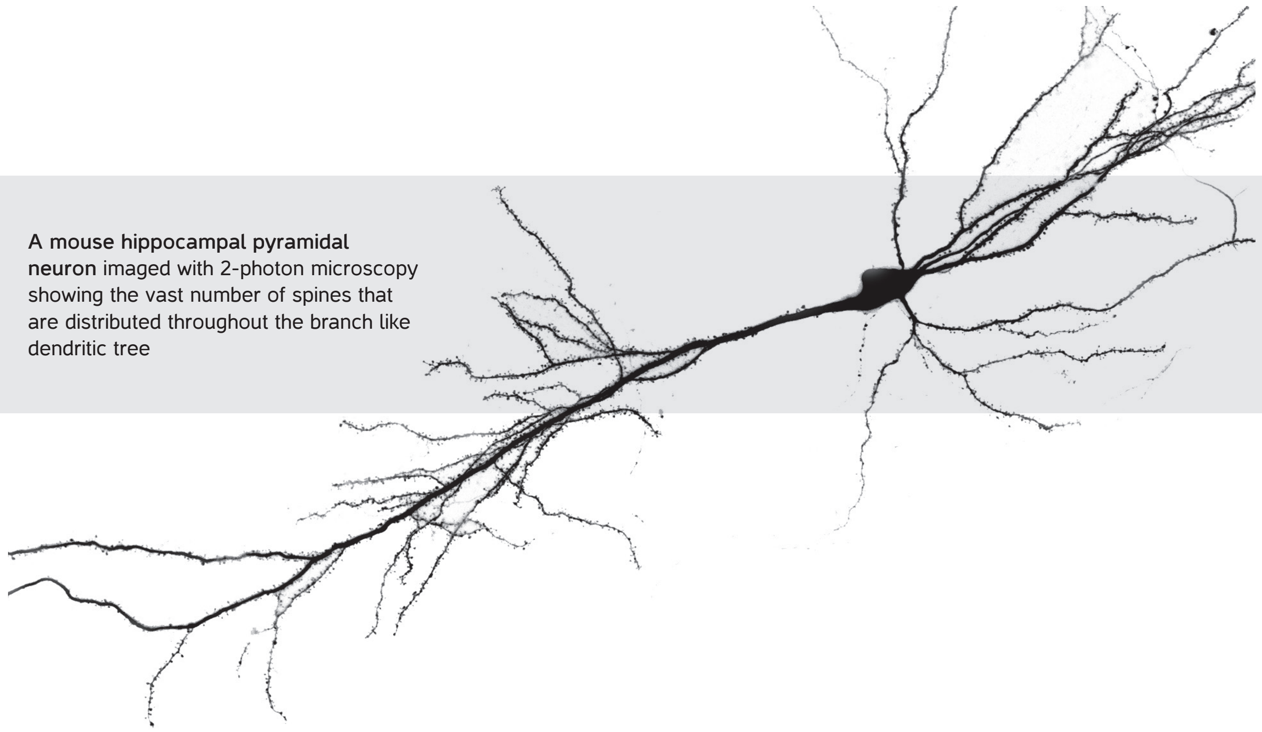
LAB MEMBERS

RESEARCH SCIENTIST
1. Daniela Pereira

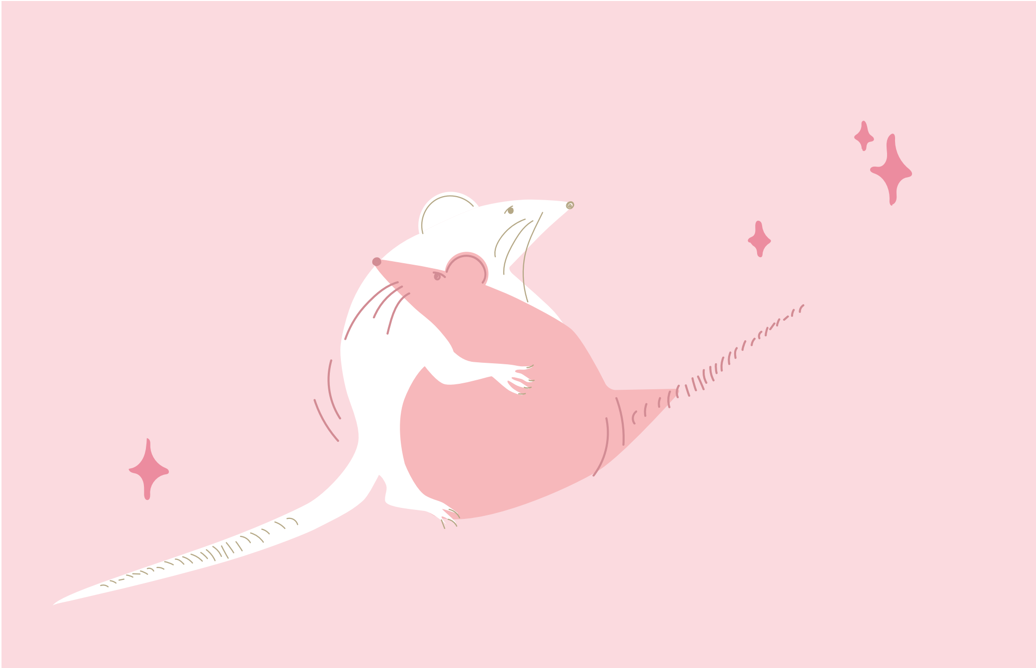
POSTDOCTORAL RESEARCHERS
2. Maria Royo
3. Nicolas Morgenstern

PHD STUDENTS
4. Ali Özgür Argunsah
5. Anna Hobbiss

RESEARCH TECHNICIAN
6. Ana Vaz



A mouse hippocampal pyramidal neuron imaged with 2-photon microscopy showing the vast number of spines that are distributed throughout the branch like dendritic tree



How does the brain control sexual behaviour?

Principal Investigator

SUSANA LIMA

Joined CF in 2008

NEUROETHOLOGY LAB

THE NEUROBIOLOGY OF SEX

Life without sex and reproduction would not only be less interesting, it would be impossible. Yet, despite its importance for the existence of the species, unlike feeding, it is not actually necessary for the survival of the individual. Still, nature developed "ways" to ensure animals do engage in sex, such as making it highly rewarding. But on the other hand, sexual behaviour must also be tightly controlled, as sex can put animals at risk by placing them in a defenseless position. Given this complicated balance of benefits and risks, how does the brain ensure that animals engage in safe and productive sexual processes?

Scientific Approach

To tackle this multifaceted problem, the Neuroethology lab focuses on several variables that influence sexual behaviour in mice. For one, as the willingness of females to engage in sex is limited to periods of fertility, the team investigates how sex hormones modulate neural activity and behaviour throughout the female reproductive cycle. Second, the team also studies the mechanisms that ensure termination of sexual interaction in males. Finally, as reward is a central component in sexual behaviour, the team also studies reward processing in the brain. To gain insight into how the brain controls these fundamental processes, the team uses a variety of techniques, including electrophysiology, genetically-based imaging methods, anatomy and many different behavioural paradigms designed to address these various aspects of sexual behaviour. The team works on several brain regions, but most of their efforts are centred on the ventral tegmental area, which is fundamental for reward processing and learning and on the medial hypothalamus, an area that is particularly important for female sexual behaviour. In fact, recent advances in the lab include the establishment of the medial hypothalamus as a brain region where hormonal state and social information are integrated.

MAIN INTERESTS:
How the brain controls key processes in sexual behaviour

METHODS:
Electrophysiology, Optogenetics, Anatomy, Behaviour

MODEL / AREA OF FOCUS:
Rodents / Medial Hypothalamus, Ventral Tegmental Area

NEUROETHOLOGY LAB

LAB MEMBERS

POSTDOCTORAL RESEARCHERS

1. Francisco Esteves
2. Kensaku Nomoto

PHD STUDENTS

3. António Dias
4. Basma Husain
5. Baylor Brangers
6. Luis Moreira
7. Silvana Araújo
8. Susana Valente

MASTER'S STUDENTS

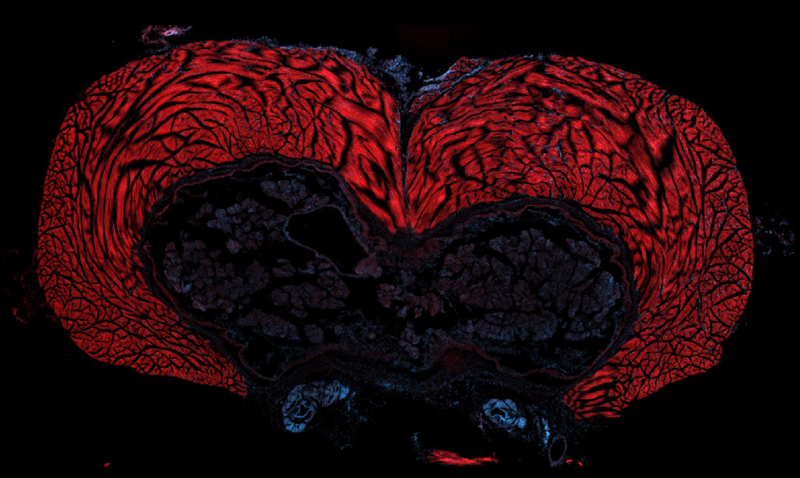
9. Ana Rita Mendes
10. Inês Preguiça
11. Diogo Matias

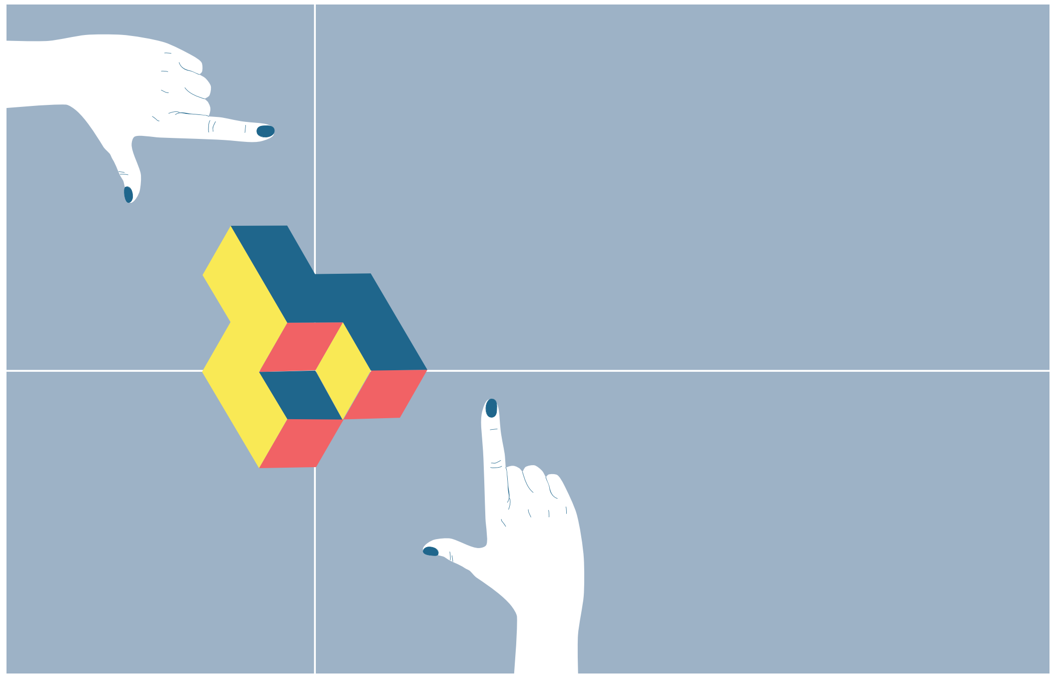
RESEARCH TECHNICIAN

12. Margarida Duarte

Viral tracing was used to outline the underlying circuitry between the muscles that control ejaculation and the brain

The image shows a cross section of the bulbospongious muscle (red) surrounding the end of the rectum (endothelium - blue).





How can information processing in the brain be mathematically modelled?

Principal Investigator

CHRISTIAN MACHENS

Joined CF in 2011

THEORETICAL NEUROSCIENCE LAB

THE MATHEMATICS OF THE BRAIN

Major breakthroughs in science are often accompanied by the identification of a mathematical way to describe complex phenomena, such as Newton's laws of motion, or the three dimensional structure of DNA. Though neuroscience has already produced several important models, it still lacks a mathematical description of how neurons in the brain coordinate their activity in order to process incoming sensory information and how they use it to act. It's one of the biggest and most complicated mysteries in the field of neuroscience. Big because little is understood at this point and complicated because it involves many interconnected autonomic units (neurons), which are intrinsically complex.

Scientific Approach

To develop models of information processing in the brain, the Theoretical Neuroscience lab uses mathematical analysis and numerical simulations. These tools allow the researchers to formulate their ideas and intuitions in a precise manner and thereby put them to a test using real data. Specifically, the team focuses on several 'higher-order' regions such as the frontal cortices that are involved in turning sensory information into decisions. As part of the recent advances in the lab, the team has developed a new method that visualises how populations of neurons represent sensory information and decisions simultaneously. In addition, other advances in the lab include the development of a theory that describes how neurons communicate shared information. This theory resulted in the successful explanation of a large set of experimental observations.

MAIN INTERESTS:
Formulating computational theories of brain function and animal behaviour

METHODS:
Mathematical Analysis, Numerical Simulations

MODEL / AREA OF FOCUS:
Rodents, Monkeys/ Frontal Lobes

THEORETICAL NEUROSCIENCE LAB

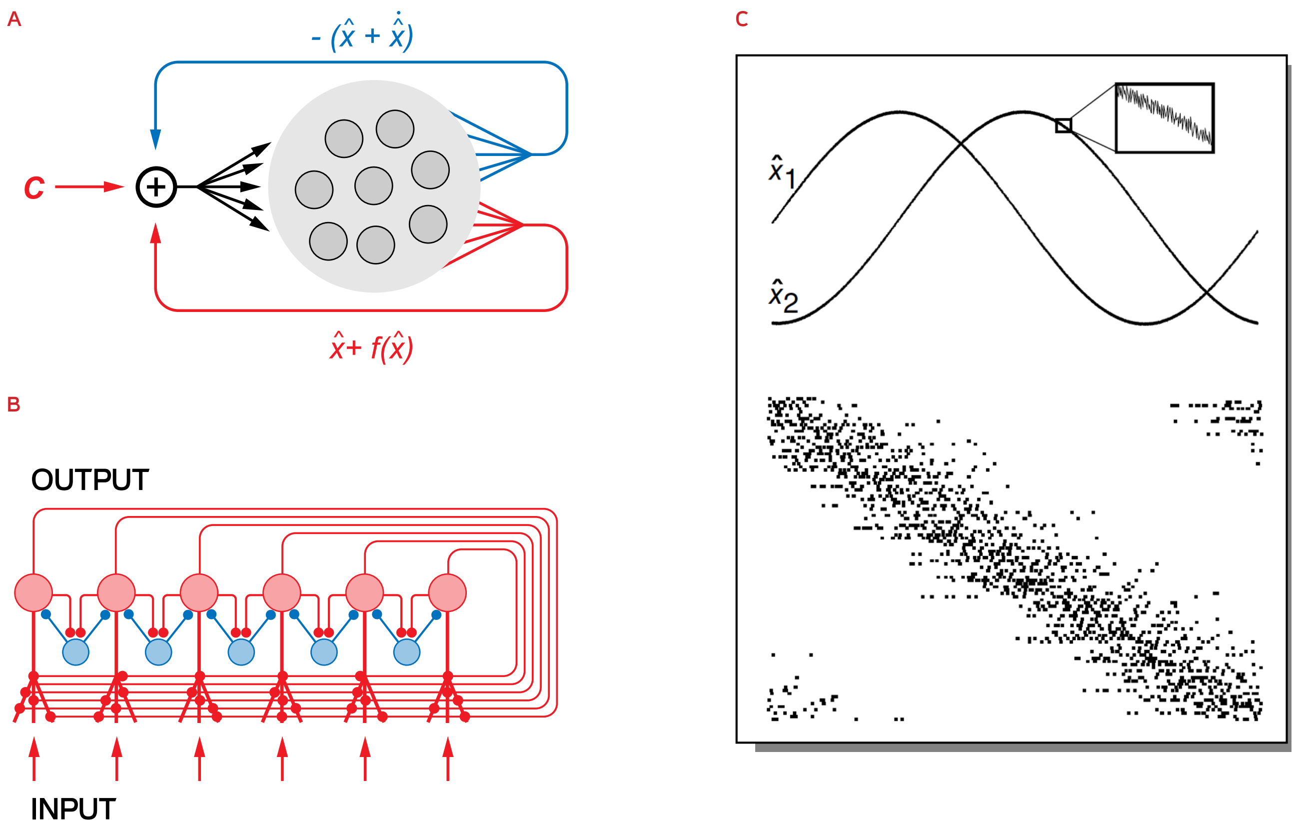
LAB MEMBERS

POSTDOCTORAL RESEARCHERS

1. Dmitry Kobak

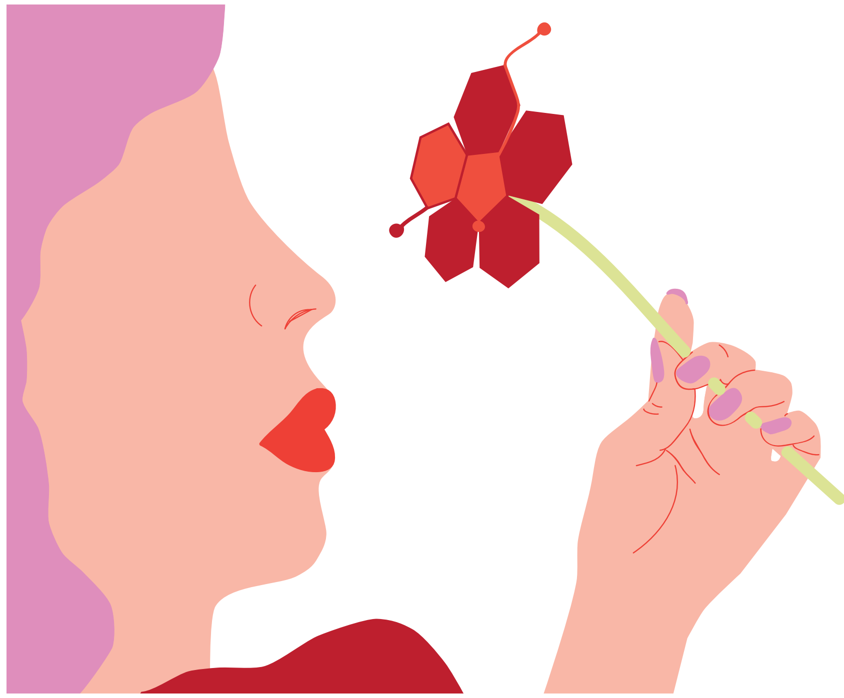
PHD STUDENTS

2. Asma Motiwala
3. João Semedo
4. Michael Pereira
5. Nuno Calaim
6. Severin Berger



Computations with tightly balanced networks

(A) A system can perform arbitrary computations if positive feedback and feedforward inputs (red) are exactly canceled by negative feedback (blue). (B) This computational scheme can be implemented in a network of excitatory and inhibitory neurons. Inhibitory neurons mediate fast inhibition (blue) that tightly balances any excitatory recurrent or feedforward inputs (red). (C) Output of a tightly balanced spiking network model that generates an oscillation and spike trains of all neurons in the network.



How does serotonin regulate our beliefs?

Principal Investigator

ZACHARY MAINEN

Joined CF in 2007

SYSTEMS NEUROSCIENCE LAB

CREATING AND EVALUATING SUBJECTIVE REALITY

We do not perceive the world directly. Rather, our brains must decipher what is out there using the window of information we receive from our senses. The result of this process is referred to as a 'model' of the world. Understanding how brains construct and use internal models is a central problem in neuroscience. This problem can be approached by thinking of the brain as a kind of an intuitive scientist, collecting and analyzing data, constructing and testing hypotheses based on those data, and revising them in light of new data. Each brain gets different data and produces a different model, making the beliefs that guide our actions subjective and sometimes wrong. Fortunately, like a good scientist, our brains can and do evaluate the quality of the data. This gives us a sense of confidence in our beliefs and decisions, helping us to know when our own subjective reality is worth acting on and when to question it. Understanding how all this works in terms of neural circuits is the long-term goal of research in the Systems Neuroscience lab.

Scientific Approach

Until recently, most research on cognitive phenomena, such as perception and decision-making, was done mainly in human and non-human primates. Together with a handful of colleagues, Mainen, head of the System Neuroscience lab, has helped to show that rodents in fact share many cognitive abilities with primates. Indeed, in 2008, his lab was the first to discover neural activity that reflected decision confidence in any species, a feat that was done in rats. Though research projects with human subjects have more recently started in the lab, this approach still dominates the Systems Neuroscience lab today, where rodents are the stars, allowing the use of advanced genetic and molecular tools not available in humans and non-human primates. Using these tools, the team is able to combine multiple techniques, which allow them to record and manipulate the neural circuits that control confidence and decision-making in relevant brain regions, such as the cortex and the midbrain. The team places a major focus on the midbrain serotonin system, which they believe to play a key role, along with other neuromodulators, in regulating beliefs. Theory and modeling are also a vital component of the work done in the lab because of the inherent complexity involved.

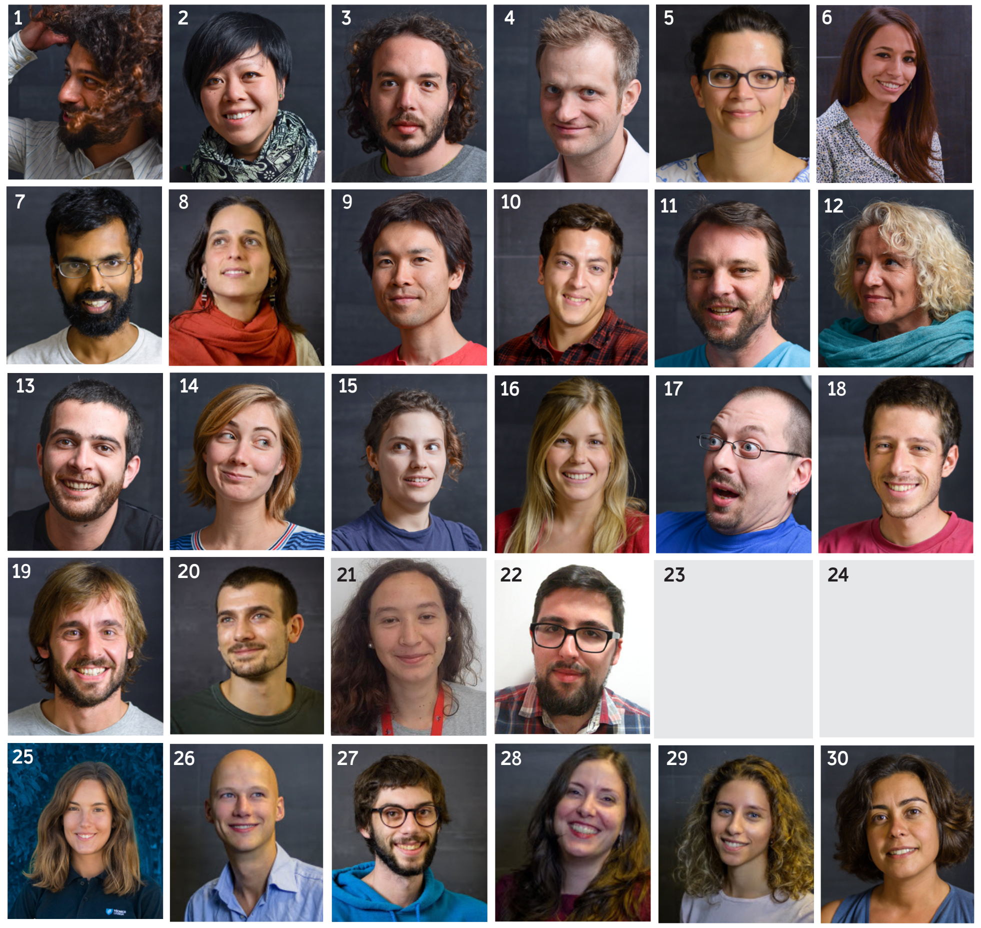
The members of the Systems Neuroscience lab are a diverse group, with backgrounds ranging from biology to mathematics, engineering and even philosophy. Lab members also count on collaborations with many groups at the CR.

MAIN INTERESTS:
How brains use perceptual information to create and act on models of the world, the role of confidence, uncertainty and neuromodulators in these processes

METHODS:
Optogenetics, Theory, Behaviour, Electrophysiology

MODEL /AREA OF FOCUS:
Rats, Mice, Humans/ Cortex, Raphe Nuclei

SYSTEMS NEUROSCIENCE LAB



LAB MEMBERS

POSTDOCTORAL RESEARCHERS

1. Bassam Atallah
2. Cindy Poo
3. Eran Lottem
4. Eric DeWitt
5. Eva Kobak
6. Fanny Cazettes
7. Gautam Agarwal
8. Maria Joana Rigato
9. Masayoshi Murakami
10. Nicolas Gutierrez
11. Paul Bush
12. Rita Venturini
13. André Mendonça
14. Sara Matias

PHD STUDENTS

15. Ana Rita Fonseca
16. Madalena Fonseca
17. Niccolò Bonacchi
18. Pietro Vertechi
19. Samuel Viana
20. Dario Sarra

MASTER'S STUDENTS

21. Marta Ferreira
22. Guilherme Freches
23. Nuno Costa
24. Tara Pimentel
25. Beatriz Godinho
26. Matthjis oude Louis

RESEARCH TECHNICIANS

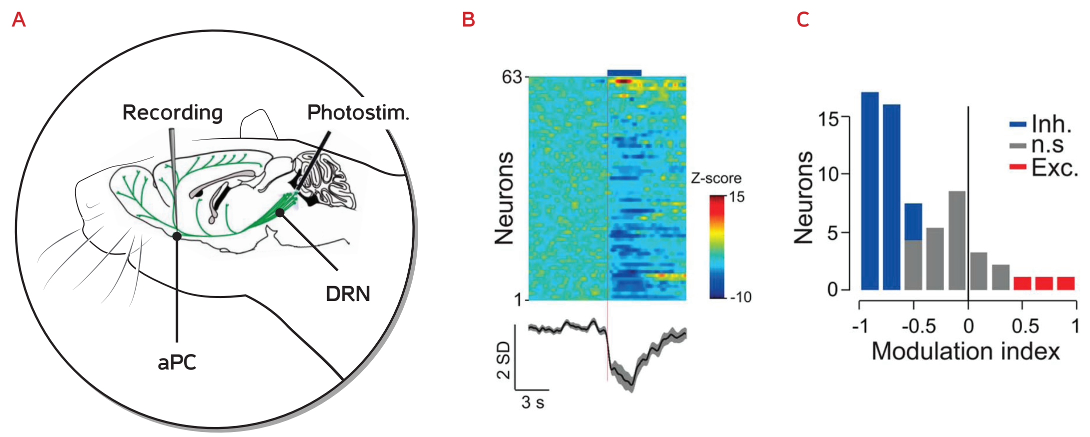
27. Tiago Quendera
28. Margarida Duarte
29. Ana Sofia Cruz

LAB MANAGER

30. Ana Nunes

DRN 5-HT photostimulation results in a prominent suppression of aPC spontaneous activity

A) Schematic of the experimental setup.Bottom, B) Top, Heat map plot of the population PSTHs (peristimulus time histograms). Bottom, Grand average z-scored PSTH of all neurons during photostimulated trials. C) ROC (receiver operating characteristic)-based MIs (modulation index) for all recorded neurons.



How do we detect threats in the environnement?

Principal Investigator

MARTA MOITA

Joined CF in 2008

BEHAVIOURAL NEUROSCIENCE LAB

THE NEUROSCIENCE OF SURVIVAL - FROM DEFENCE TO COOPERATION

Behaviours that are crucial for survival are likely to have shaped the brain throughout evolution. Animals face a multitude of dangers, many of which can be life-threatening, such as attacks by predators and insufficiency of vital resources. Therefore, several mechanisms of defensive behaviours have evolved, of which many are similar across the animal kingdom. In addition, social behaviour is crucial for survival in many species. Living in groups provides a number of advantages such as help with defence, through the sounding of alarm signals for example, and the division of labour, such as when groups of females share the care of their young. These two different types of behaviour raise many questions such as how animals detect threats in the environment, how they choose which defensive strategy to adopt and what drives animals to cooperate with each other.

Scientific Approach

To address these questions, the Behavioural Neuroscience lab uses two different animal models, rats and fruit flies. To study how animals use cues from conspecifics for threat detection, the team uses rats. A great deal is known about the brain mechanisms that drive defensive behaviours in rodents, though those by which social information is used to detect threats remains largely unanswered. To address this question the lab develops new behavioural tasks that allow the dissection of the social cues used by rats. At the brain level, the team focuses on the amygdala, a structure that regulates defensive responses and the areas that send information to it. To do so, experiments in the lab combine genetically based techniques and pharmacology to manipulate the activity of neurons in the brain regions of interest. Once a threat is detected animals need to choose the appropriate action. Many times defensive behaviours are carried out at the level of the population, such as shoaling in fish. To investigate the neural mechanisms of social defense responses, the team uses the fruit fly, an ideal model system for its large collection of powerful genetic tools, a rapidly increasing number of approaches to study neural circuits and expanding set of behavioural paradigms. The team is currently developing an assay to dissect social defensive behaviours in flies across large groups of individuals.

MAIN INTERESTS:
Defensive and social behaviour

METHODS:
Development of Behavioural Tasks, Optogenetics, Pharmacology, Physiology

MODEL /AREA OF FOCUS:
Rat, Fruit Fly / Amygdala, Auditory Thalamus, Cortex

BEHAVIOURAL NEUROSCIENCE LAB

LAB MEMBERS

POSTDOCTORAL RESEARCHERS

1. Clara Ferreira
2. Natalia Barrios
3. Ricardo Neto Silva

PHD STUDENTS

4. Andreia Cruz
5. Ricardo Zacarias
6. Scott Rennie

RESEARCH TECHNICIANS

7. Alexandra Medeiros
8. Matheus Farias

Two rats interacting in a double T-maze designed to study collective decision-making. The image is taken from Bonsai which we used for video-based tracking of the rats.

Why do some cells die while others survive?

Principal Investigator
EDUARDO MORENO
Joined CF in 2016

CELL FITNESS LAB

SURVIVAL OF THE FITTEST

How do the many millions of single cells that make up the body interact to ensure the integrity and smooth functioning of the "individual"? Though seemingly serene from the outside, the world inside is far from it. It is, in fact, teeming with interactions that at times follow a peaceful path of cooperation and at times one of competition and death. Like humans, single cells grow old and their performance decays through use and damage. Just as we are able to detect fitness decay in our human colleagues by looking at the graying of their hair, or the wrinkles in their faces, so are cells able to recognise decay in their neighbours. Once cells recognise an unfit neighbour they bring about its death and often replace it with a younger, healthier cell. Despite the crucial importance of this fundamental process and its implication into several broader fields, such as development, ageing, regeneration and cancer, the molecular mechanisms that underlie it are still largely unknown.

Scientific Approach

To uncover the mechanisms of cell competition, the Cell Fitness group studies its role in processes such as aging, development, tissue regeneration and cancer. Work from the team has provided significant insight into these mechanisms, including the identification of "fitness fingerprints", a molecular code used by cells to exhibit their fitness level. The team has demonstrated how those fitness fingerprints are exhibited by less fit cells and can be used to mediate cell selection by allowing neighbouring cells to recognise and eliminate these cells. The team has shown that this process happens during ageing, regeneration and cancer. Specifically, they found that fitness-based cell selection could be manipulated to delay ageing and tissue fitness decay as well as to prevent the expansion of cancer cells, which often exhibit themselves as "super-fit" cells, leading the normal healthy cells around them to be eliminated by using this same mechanism of cell competition. In 2016, the team discovered a new type of competition named "mechanical competition", in which high density of cells leads to compression of tissue and thereby to cell elimination. The team proposes that this process may be important for tumour expansion into healthy tissue and is currently in the process of testing this hypothesis.

Work in the lab is done in the fruit fly animal model, where advanced genetic techniques are applied to manipulate the functions of genes related to cell fitness, in combination with microscopy and live imaging used to track how different genetic manipulations influence cell competition. Specifically, the team studies epithelial tissue, which is known to give rise to 95% of cancer types, including breast, lung and skin cancer. They also study the role of fitness-based cell selection among neurons during brain development, neurodegeneration and brain ageing. Finally, they are currently studying the conservation of the process in human cells and in mouse models.

MAIN INTERESTS:
The mechanisms by which cells of multicellular animals perform fitness detection and selection of neighbouring cells

METHODS:
Genetics, Microscopy, Live Imaging

MODEL /AREA OF FOCUS:
Human Cells, Mouse, Fruit Fly / Epithelial, Neuronal Tissue

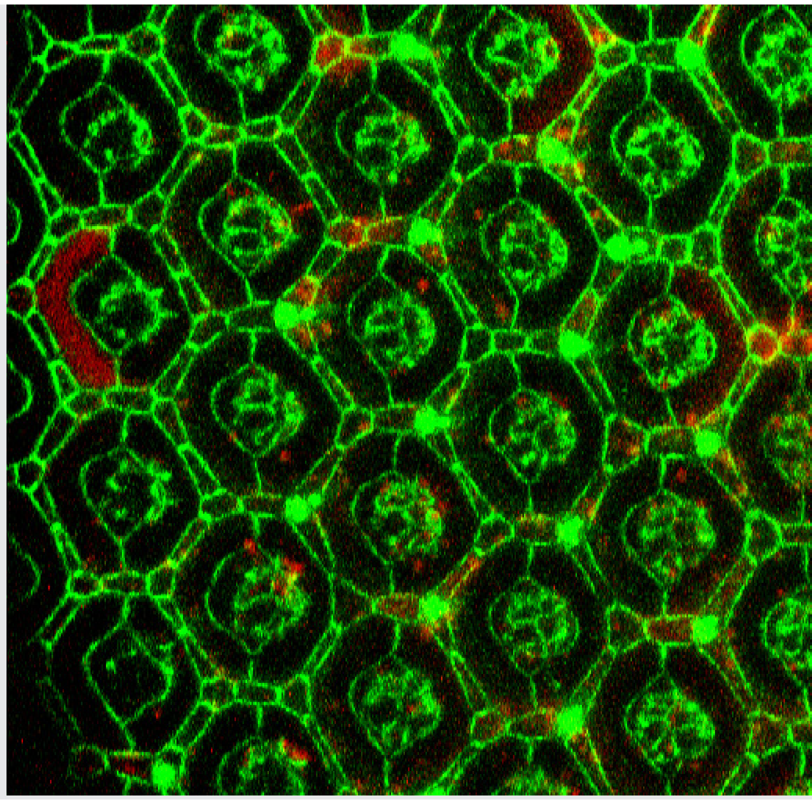
CELL FITNESS LAB LAB

LAB MEMBERS

POSTDOCTORAL RESEARCHERS
1. Catarina Brás Pereira
2. Dina Coelho Da Silva

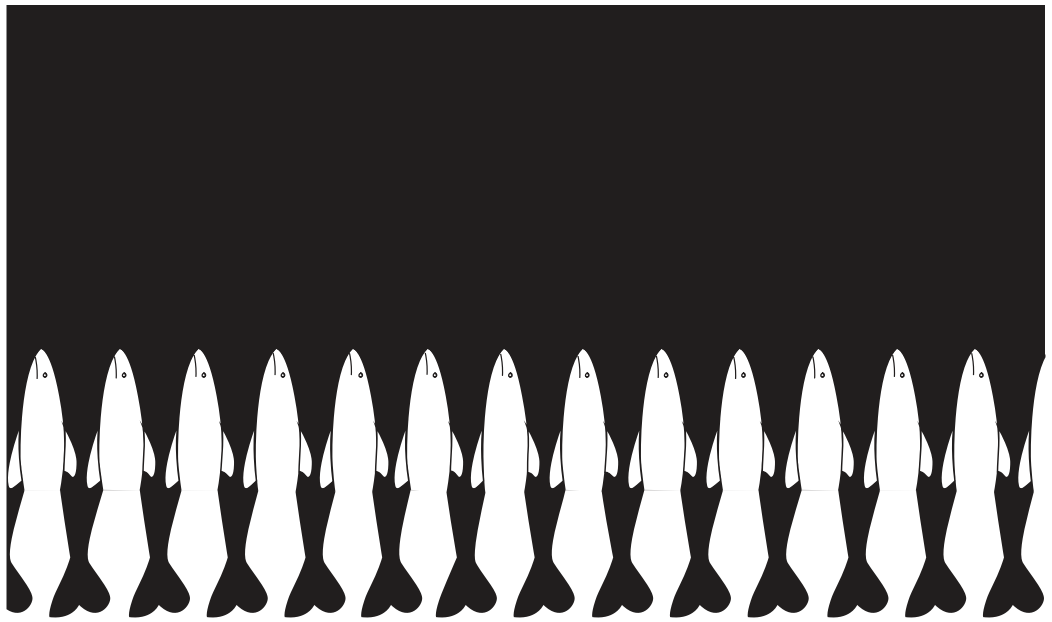
PHD STUDENTS
3. Andrea Spinazzola
4. Andrés Gutiérrez
5. Irene Argudo
6. Maria Bettencourt
7. Maria Carolina Rodrigues
8. Isahak Saidi

MASTER'S STUDENTS
9. Inês Silva
10. Catarina Rato
11. Mariana Marques dos Reis



Neurons of the *Drosophila* retina (green) undergoing fitness-based selection (red).

How do zebrafish larvae navigate the world?



Principal Investigator

MICHAEL ORGER

Joined CF in 2010

VISION TO ACTION LAB

WATCHING HOW THE BRAIN NAVIGATES THE WORLD

Standing on the beach on a clear, sunny day you are watching the waves when you suddenly notice an airborne object speeding towards you. Do you jump out of its path, or do you try to catch it? Your reaction depends on your brain's ability to extract relevant features of sensory visual input and guide appropriate motor actions. Similar reflexive behaviours can also be seen in zebrafish larvae that, at just a week old, are naturally able to escape predators, or catch prey. Though seemingly relatively simple, reflexive behaviours such as these actually depend on activity generated in complex networks of neurons that are distributed across the entire brain. Discovering how these dynamics unfold throughout the brain on the level of single neurons during behaviour is crucial in order to formulate the principles on which these sensorimotor circuits are organised.

Scientific Approach

To tackle these challenges, the Vision to Action lab uses a combination of advanced optical, genetic and behavioural methods in zebrafish. In recent years, zebrafish have emerged as an attractive model system, as they exhibit a robust set of instinctive visually guided behaviours, while their brain, which follows a typical vertebrate pattern, is sufficiently small and transparent so that researchers can non-invasively image the activity of each of its neurons. Specifically, the team follows the activity of neurons by imaging changes in calcium levels inside neurons, a marker of neural activity, while performing high-speed behaviour tracking to make a detailed, quantitative analysis of visually evoked swimming and eye movements. In addition, the team develops genetic tools in order to probe and manipulate defined circuit elements with high specificity.

Recent work from the lab described, at single neuron resolution, the neural activity dynamics throughout the brain of behaving zebrafish. While even very simple behaviours involve activity in hundreds of neurons distributed across many brain regions, the team found that these elaborate patterns are consistent across individuals down to a very fine anatomical spatial scale. In addition, the team has also developed a high-speed, real-time tracking system that has allowed them to systematically characterise the swimming behaviour of zebrafish larvae in response to a variety of different stimuli. Using a computational approach to behaviour classification, called unsupervised machine learning, they have identified a core set of swimming movements, and demonstrated how they are used flexibly across different behaviours.

MAIN INTERESTS:
Determine the principles on which sensorimotor circuits are organised and reveal how activity dynamics unfold throughout the whole brain during behaviour

METHODS:
High-Speed Behaviour Tracking, Optogenetics, Whole-brain Calcium Imaging, Genetics

MODEL /AREA OF FOCUS:
Zebrafish / Whole Brain

VISION TO ACTION LAB

LAB MEMBERS

RESEARCH ASSOCIATE
1. Claudia Feierstein

POSTDOCTORAL RESEARCHERS
2. Ana Raquel Tomás
3. Sabine Renninger

PHD STUDENTS
4. Jens Bierfeld
5. João Marques
6. Rita Félix
7. Simone Lackner

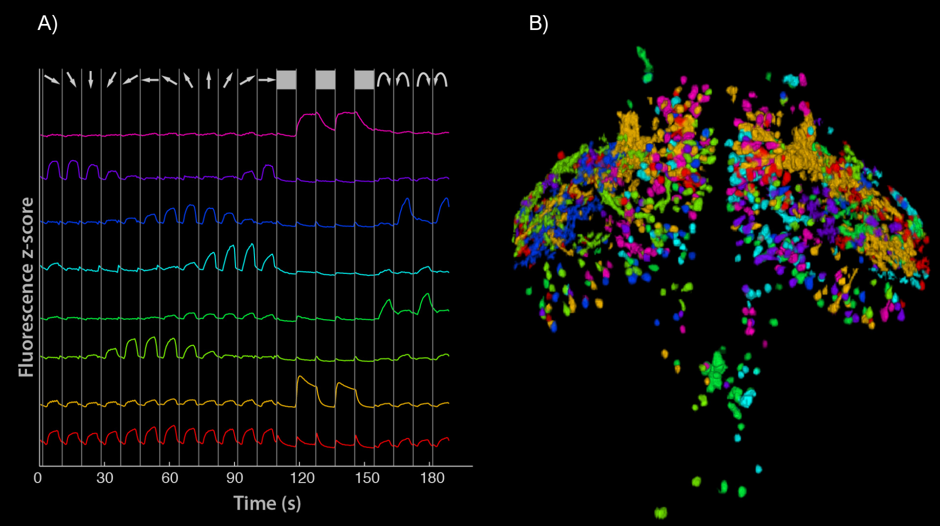
MASTER'S STUDENTS
8. Rita Esteves

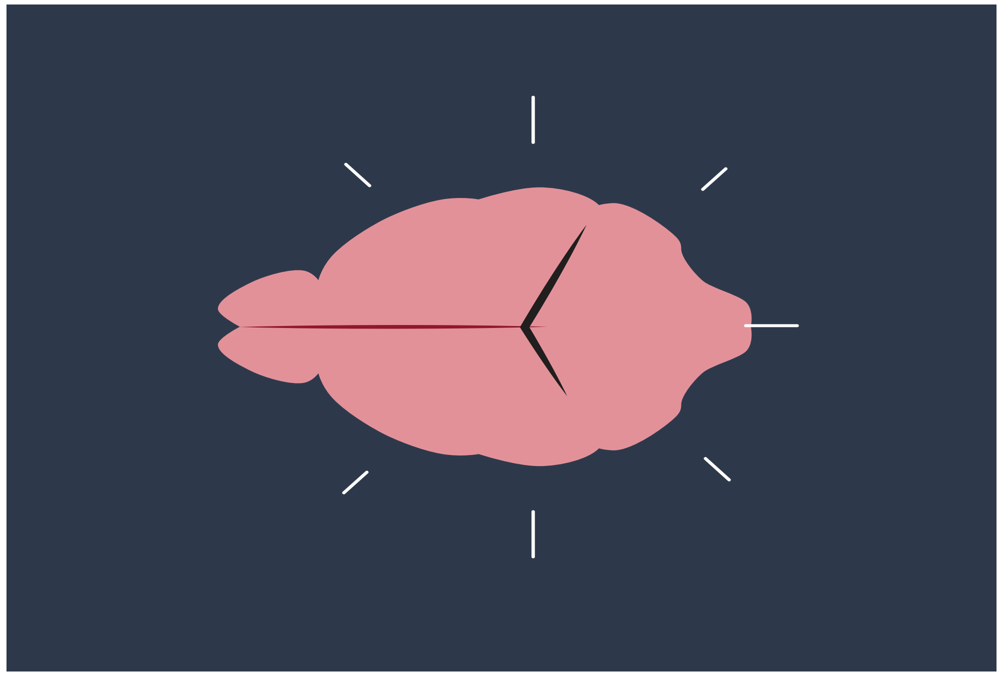
RESEARCH TECHNICIANS
9. Alexandre Laborde
10. António Martins

Functional clusters of visually responsive neurons in the larval fish brain.

A) Average fluorescence traces of voxel clusters from whole-brain imaging data in response to whole-field motion and illumination changes.

B) Neurons and their processes color-coded by cluster identity in a genetically targeted cell population.





How does the brain track the passage of time?

Principal Investigator

JOE PATON

Joined CF in 2008

LEARNING LAB

PINNING DOWN THE NEURAL CLOCK

For our ancient ancestors learning was necessary for survival. Will these berries make me ill? Which birdcalls announce the approach of a tiger? Millennia have passed, but to be a successful, or at least an adequate human, we still need to learn about the world. Even trivial tasks such as calling the elevator require learning – making a mental connection between two events separate in time. How is the brain able to create these connections, which can happen either seconds, minutes, or even hours apart? Are there neural clocks ticking away somewhere inside our brains drawing invisible lines between cause and effect?

Scientific Approach

One of the major challenges in studying timing is that time is inevitably associated with changes in other variables, such as movement, or sensation. Therefore, the behaviours tested in the Learning lab are carefully chosen to help separate neural activity which is related to time from other ongoing variables. The team studies these behaviours in rats and mice while simultaneously recording the activity of multiple neurons and manipulating their activity. This way, the team can observe how information about time can be encoded across networks of neurons. Indeed, one of the lab's largest contributions thus far has been to discover that information about elapsed time can be encoded in a kind of wave of activity that travels slowly across populations of neurons in the basal ganglia, an area known to be important for timing.

In addition to the basal ganglia, the team also studies the thalamus and frontal areas of the cortex. These frontal areas specifically are optimal sites for studying timing behaviour as they are thought to be involved in the association of experienced positive outcomes with the choices and actions that have led to them, or in other words, creating a mental connection between causes and positive effects. A deeper understanding of these areas could have far reaching implications for grasping how people function in both healthy and pathological conditions such as addiction or Parkinson's disease.

MAIN INTERESTS:
How the brain learns what to do and when to do it

METHODS:
Behaviour, Neurobiology, Molecular Biology, Mathematical Modelling

MODEL / AREA OF FOCUS:
Rodents / Basal Ganglia, Thalamus, Frontal Areas of the Cerebral Cortex

LEARNING LAB

LAB MEMBERS

POSTDOCTORAL RESEARCHER

1. Tiago Monteiro

PHD STUDENTS

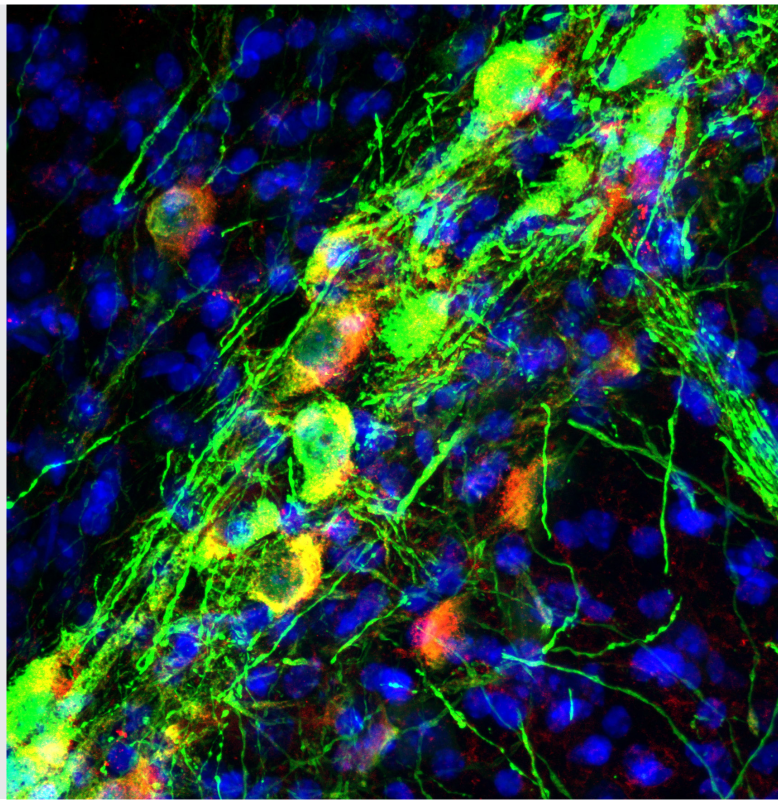
2. Bruno Cruz
3. Gustavo Mello
4. Mauricio Toro
5. Sofia Soares
6. Thiago Gouvêa

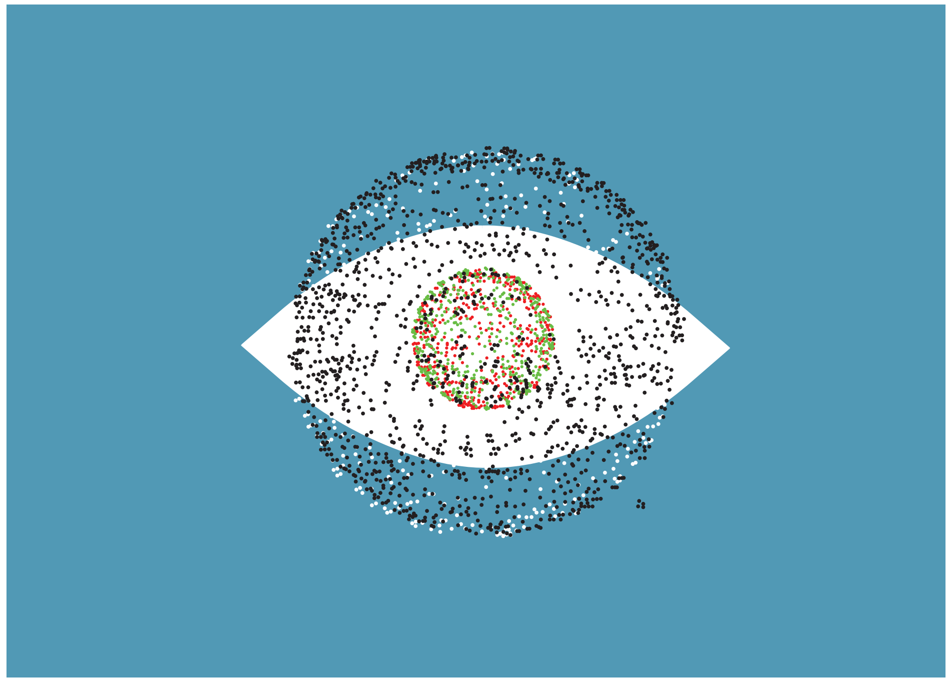
RESEARCH TECHNICIAN

7. Filipe Rodrigues

Confocal stack of the *substantia nigra pars compacta*.

The image shows three channels taken from a DAT-Cre mouse where the calcium indicator GCaMP6f (green) and tdTomato (red) are expressed specifically in dopamine neurons. In blue, DAPI staining (4',6-diamidino-2-phenylindole) for nucleic acids.





How is the visual flow of information coded across networks of neurons?

Principal Investigator

LEOPOLDO PETREANU

Joined CF in 2012

CORTICAL CIRCUITS LAB

EAVESDROPPING ON THE BRAIN: WHAT DO DIFFERENT AREAS TALK ABOUT?

The neocortex is a seemingly simple sheet of neurons located at the outermost part of the brain. But appearances can be deceiving. In fact, the neocortex is the part of the brain that endows us with the advanced cognitive abilities that we are capable of. Despite its uniform appearance, the neocortex is composed of a set of specialised areas that interact with each other, thereby forming a complex network. Each action we take depends on the network's ability to communicate information across different regions and combine functions. For example, we wouldn't be able to catch a ball if different parts of our visual system were not engaged in continuous and rapid interaction. It is known that communication among brain areas is done through a part of the neuron called an axon, which functions as a long "wire" that connects neurons both locally and across different brain areas. However, what is the exact nature of the information that is sent out across areas and how it is "heard" by the target areas and incorporated into their own functioning still remains to be known.

Scientific Approach

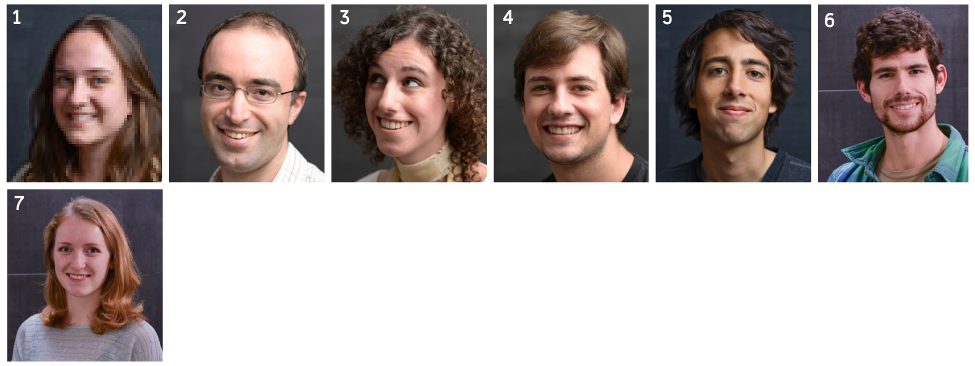
The members of the Cortical Circuits lab study the areas that are required for visual processing in rodents, while focusing on the axons that link distant visual areas both within the cortex and between the cortex and the thalamus. It is important to note that recording the activity of single axons is no small feat, as axons are extremely thin wires, whose diameter measures a mere micrometer (a millionth of a meter) or less. Therefore, the investigators apply special methods developed in the lab, which enable them to map the connectivity of these axons with unprecedented detail. Technical advances in the lab include the development of a novel method to study how information received from distant brain areas is integrated by groups of neighbouring neurons in the target area. Using this method, in an article published in the journal Nature Neuroscience in 2016, the researchers shared a newly discovered connectivity map between the thalamus and primary visual cortex, providing important insight into how visual information is processed in the brain. Other projects currently running in the lab aim to understand the logic of inter-areal interactions by recording and manipulating axons while animals perform visual tasks.

MAIN INTERESTS:
How different brain areas interact with each other

METHODS:
Imaging, Electrophysiology, Behaviour

MODEL /AREA OF FOCUS:
Rodents / Visual Cortex

CORTICAL CIRCUITS LAB



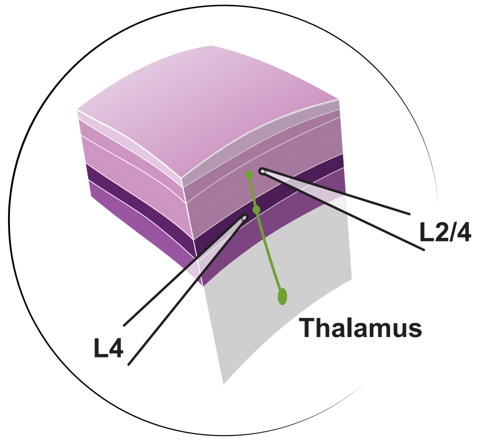
LAB MEMBERS

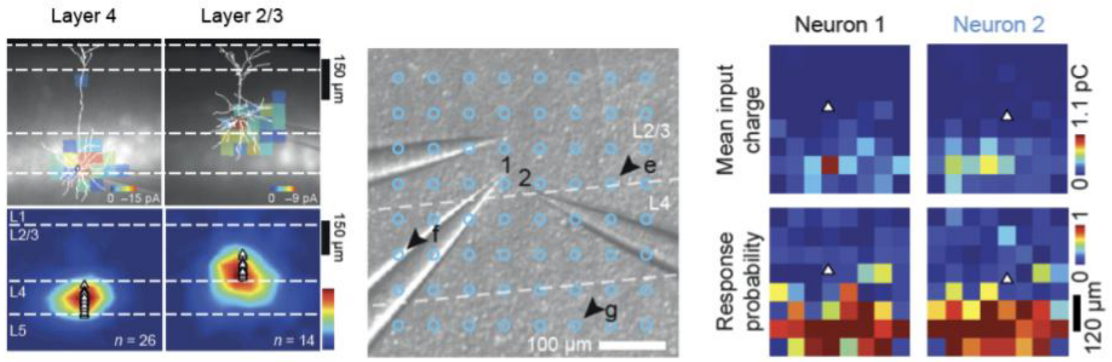
PHD STUDENTS

1. Gabriela Fioreze
2. Hedi Young
3. Marina Fridman
4. Rodrigo Dias
5. Tiago Marques

MASTER'S STUDENTS

6. Shane Beato
7. Vera Van der Steen

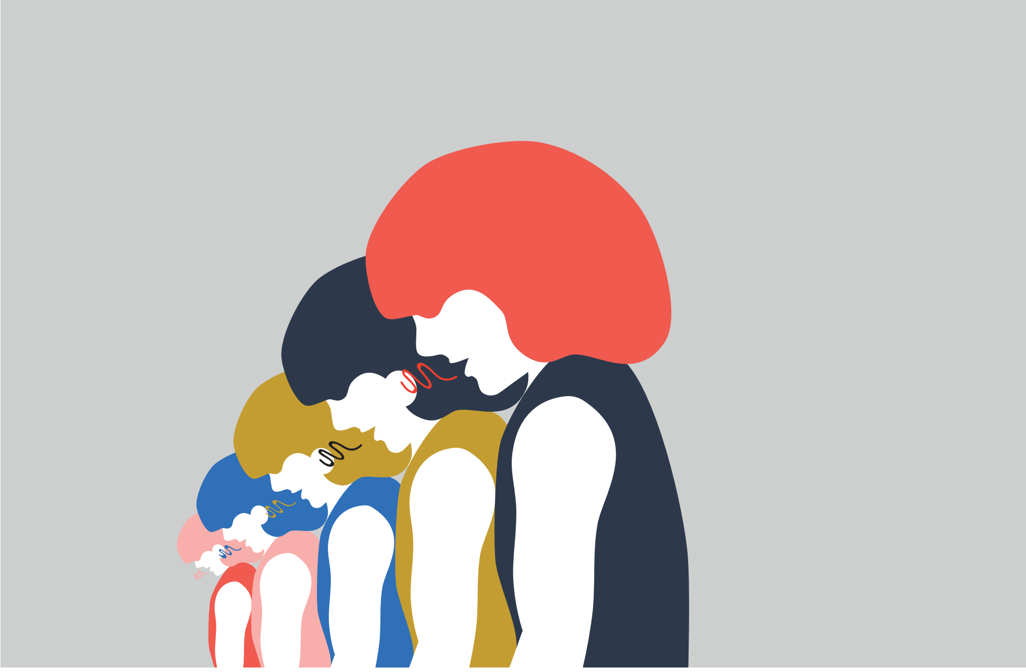




The lab developed a new method to measure **how inputs from axons from distant brain regions are integrated by groups of neighboring neurons.**

The image shows that axons relaying visual information from the thalamus tend to contact groups of interconnected neurons in the cortex.

How does the brain represent auditory information to make decisions?



Principal Investigator

ALFONSO RENART

Joined CF in 2011

CIRCUIT DYNAMICS AND COMPUTATION LAB

UNDERSTANDING COMPUTATIONS PERFORMED BY NETWORKS OF NEURONS

Processes such as sensing, remembering, or deciding are computations accomplished through the exchange of nerve impulses by networks of neurons in the brain. Although the way in which single neurons use electrical activity to emit pulses is relatively well understood, neurons in the brain do not operate in isolation, and the trains of pulses from one neuron affect and are affected by the nerve impulses of the neurons with which it is connected. Since it is now possible to monitor the activity of hundreds of neurons simultaneously, it is becoming feasible to describe how neurons coordinate their activity in the living brain. Formulating general principles describing how neurons in key brain areas work together while animals solve specific tasks is an important step for understanding how the brain computes.

Scientific Approach

The goal of the Circuit Dynamics and Computation lab is to understand how the dynamics of networks of neurons allows them to solve particular problems. Although the team's ultimate objective is to understand neural computation at the circuit level in mathematical terms, they believe that, at the moment, the most effective approach to achieve this goal is to use a combined experimental-theoretical approach. This is because the available experimental evidence describing the activity of neuronal circuits during specific computations is too scarce to formulate accurate theories. The lab's approach is therefore to first design behavioural tasks for rats and mice that isolate a specific computation, second, to record the simultaneous activity of many neurons during performance of these tasks, and finally to use mathematical methods to analyse this data and to generate models of how these computations are implemented. Specifically, the team is studying a variety of problems, among which two central ones are the way in which sensory areas in the cerebral cortex represent auditory information and use it to make simple decisions, and the way in which associative areas in the prefrontal cortex mediate short-term memory, by guiding actions using sensory information no longer present in the environment. Some of this work is done in collaboration with the Theoretical Neuroscience lab and with the Systems Neuroscience lab.

MAIN INTERESTS:
Identifying generic principles governing the dynamics of cortical circuits and the way in which they produce function

METHODS:
Behaviour, Electrophysiology, Analysis, Theory

MODEL /AREA OF FOCUS:
Rodents, Human / Auditory Cortex, Prefrontal Cortex

CIRCUIT DYNAMICS AND COMPUTATION LAB

LAB MEMBERS

POSTDOCTORAL RESEARCHERS

1. José Pardo-Vazquez
2. Nivaldo Vasconcelos
3. Tor Stensola

PHD STUDENTS

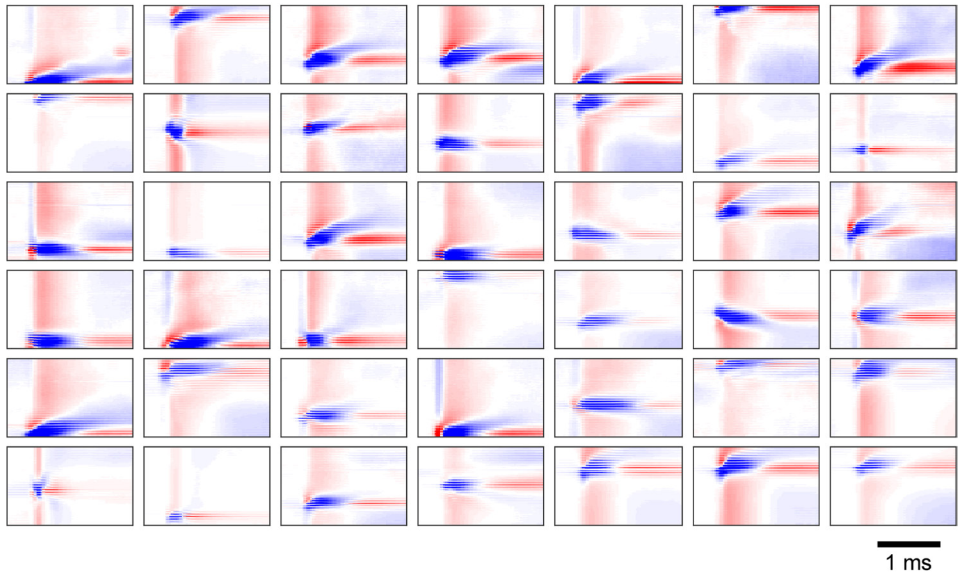
4. Jacques Bourg
5. João Afonso
6. Raphael Steinfeld
7. Roberto Medina

MASTER'S STUDENTS

8. Julien Fiorilli
9. Ana Mafalda Valente

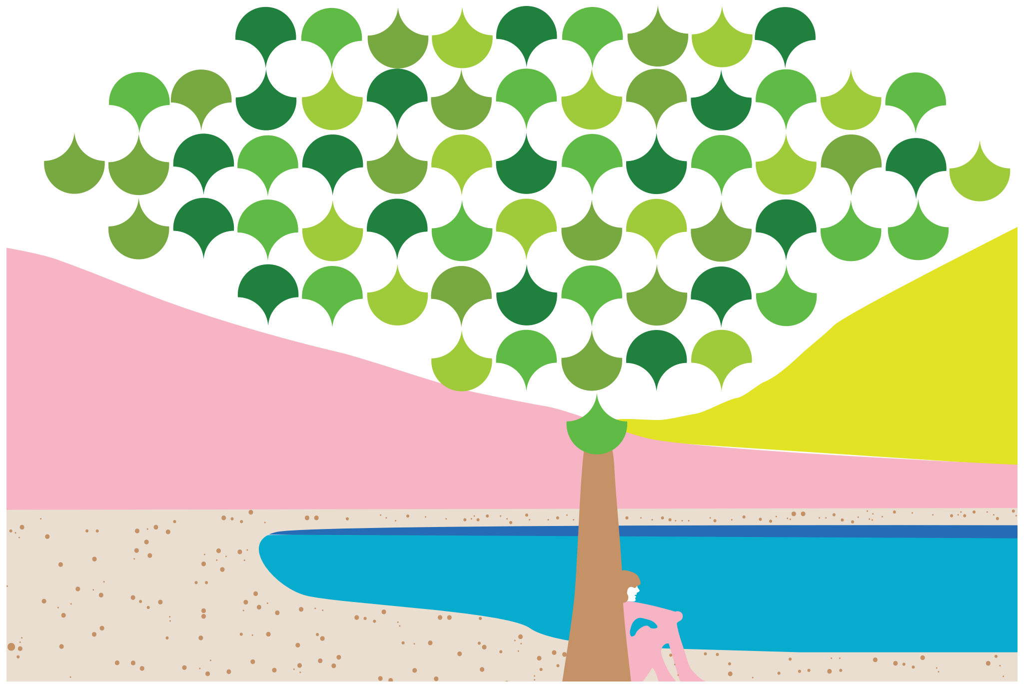
RESEARCH TECHNICIAN

10. Juan Castiñeiras



Spatio-temporal dynamics of extra-cellular action potentials.

Each plot shows the action potential of a simultaneously recorded neuron from a 128-channel silicon probe. Each row in each plot shows the voltage deflection due to the action potential in colour, and different recording sites are arranged according to their depth in the cortex. The diagonal blue area in each plot shows the back-propagated action potential, and the red area shows return currents.



Can lost groups of neurons be reconstructed by activating stem cells?

Principal Investigator

CHRISTA RHINER

Joined CF in 2016

STEM CELLS AND REGENERATION LAB

STEM CELLS TO THE RESCUE!

Loss of neurons in the adult brain can happen through injury and disease and may lead to devastating, often irreversible results. An emerging field in biology aspires to reconstitute lost groups of neurons through the activation of stem cells, which exist in many body tissues including the brain. Repopulation of the damaged area by stem cells progenies is thought to hold the potential to promote recovery of lost function. At the same time, misregulated proliferation of stem cells may lead to tumour growth and metastasis. In order to both effectively utilise stem cells to fight the consequences of neuronal loss, and to prevent their misuse through cancer, researchers are now focusing on understanding the mechanisms that control stem cell activation and specialisation.

Scientific Approach

The Stem Cells and Regeneration lab is interested in isolating the factors that bring about activation of adult stem cells during tissue regeneration after injury or tumour formation. To that end, the team studies the molecular mechanisms through which neural stem cells are activated and produce new nerve cells in the adult brain. The methods utilised in the lab include genetics, RNA-sequencing, high-end confocal microscopy and behavioural assays to test recovery of neural function. The team applies these methods in the adult fruit fly brain, within a region called the optic lobe. Recent work from the lab has resulted in the discovery of damage-responsive stem cells in this area and the identification of several candidate genes that are thought to underlie this process. Currently, the team is characterising these genes while concurrently working on identifying other brain regions that are able to regenerate. Ultimately, the team's discoveries may lead to new therapies to facilitate tissue repair, such as brain regeneration after stroke, and preventing dysregulated stem cell proliferation that may lead to tumour formation.

MAIN INTERESTS:
How adult stem cells can switch from being dormant to actively dividing in situations relevant for tumour formation or tissue regeneration after injury

METHODS:
Genetics, RNA-sequencing, Confocal Microscopy, Behavioural Assays

MODEL /AREA OF FOCUS:
Fruit Fly / Entire Brain

STEM CELLS AND REGENERATION LAB

LAB MEMBERS

POSTDOCTORAL RESEARCHER

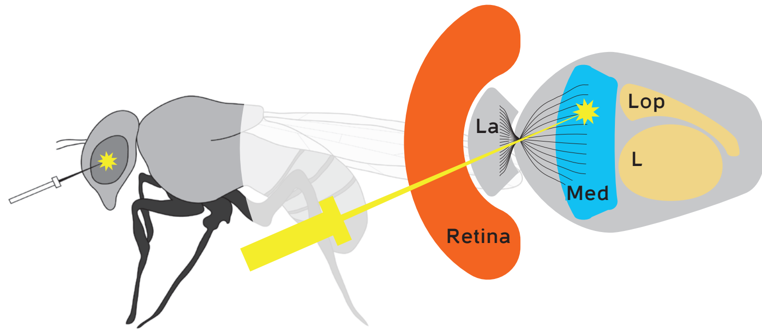
1. Silvia Schwartz

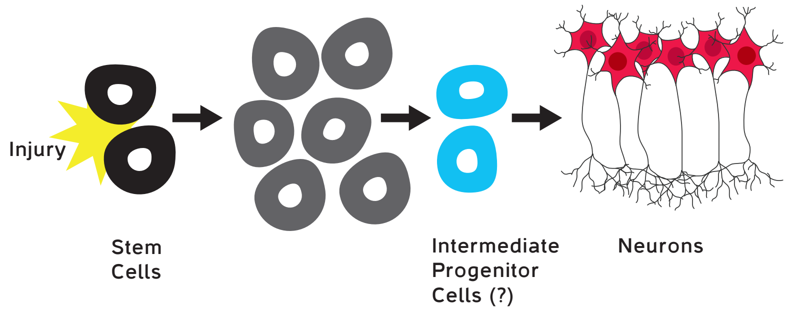
PHD STUDENT

2. Anabel Rodriguez Simões

MASTER'S STUDENT

3. Carolina Alves

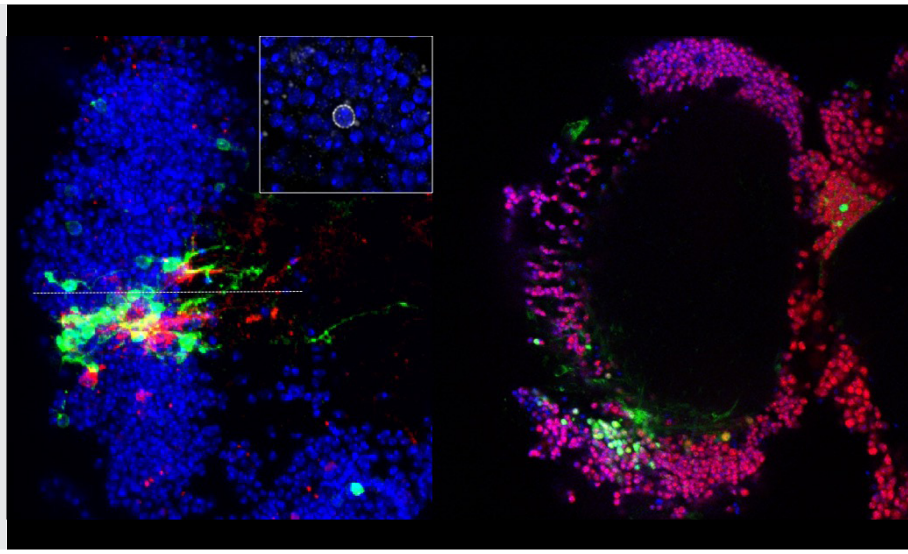


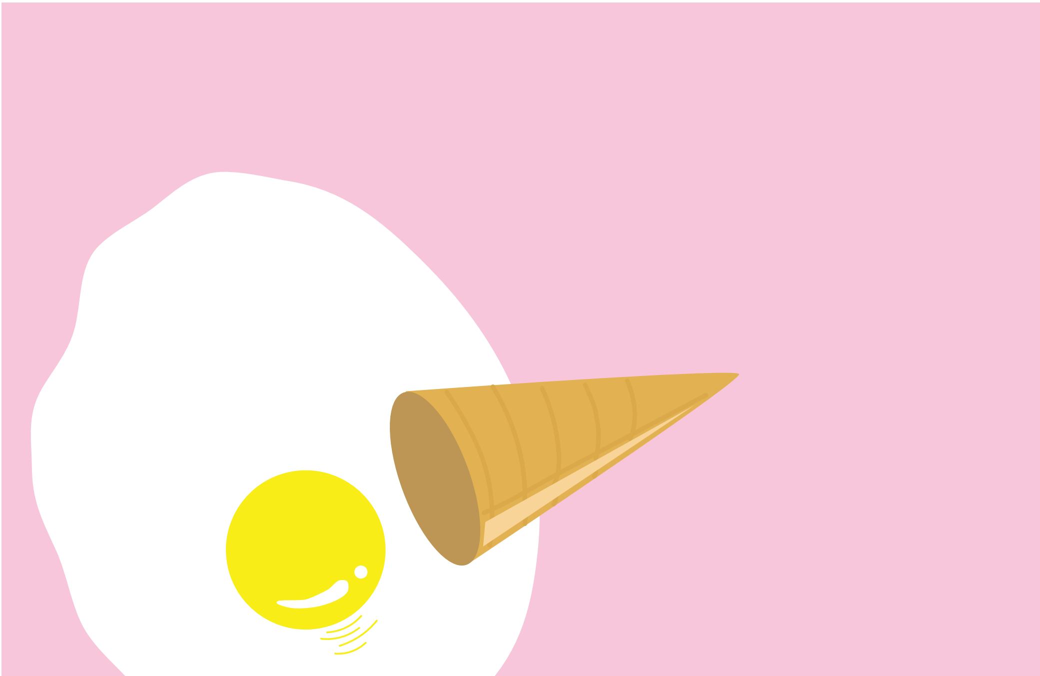


Regenerative neurogenesis in Drosophila

Left: 6 days after brain injury, new neurons (marked in red and green) have integrated into the damaged brain area marked by the dashed line. Cell nuclei are stained in blue.
Inset: quiescent neural stem cell in the adult fly brain.

Right: Traumatic brain injury leads to rapid induction of a reporter of the JNK stress response pathway (green) in neurons (red). Cell nuclei are marked in blue.





How does the brain control food choice?

Principal Investigator
CARLOS RIBEIRO
Joined CF in 2009

BEHAVIOUR AND METABOLISM LAB

THE HUNGRY BRAIN - PURSUING THE NEURAL CIRCUITS THAT DETERMINE FOOD CHOICE

The food we eat affects all aspects of our lives, including aging, ability to reproduce, lifespan, mental state and mood. For better or worse, we are what we eat. Yet, how the brain controls food choice is still a mystery. What are the neural processes that drive us to choose a pretzel over an apple, or a steak over ice cream? To tap into this problem researchers have to tackle difficult questions such as how the brain knows which nutrients the body needs to stay healthy and how this information is translated into action.

Scientific Approach

The Behaviour and Metabolism lab addresses these questions by using the fruit fly *Drosophila melanogaster*, one of the most powerful genetic animal models currently available. The fruit fly offers an impressive set of tools and techniques, which include, among many others, genetic circuit manipulations, activity imaging, automated, quantitative methods for studying behaviour, and neuroanatomy. Team members use the full set since it enables them to implement an integrative neuroscience approach, necessary in solving this whole-organism problem. Since nutrient decisions have implications that pertain to the entire organism, the lab's work leads it to probe neural circuits ranging from those that mediate taste and smell perception to those involved in the mating response. One of the lab's recent advances, for instance, was the discovery of a female neuronal pathway that begins with mating, continues with changes in sensory salt perception in female flies and culminates with alterations in their preference for salty food, bringing to mind the well-known phenomenon of food cravings during pregnancy.

MAIN INTERESTS:
The neural mechanisms of nutrition

METHODS:
Optogenetics, Nutritional Manipulations, Molecular and Biochemical Methods, Neuroanatomy, Microbial Manipulations of the Host, Behaviour

MODEL /AREA OF FOCUS:
Fruit Fly / Whole Brain

BEHAVIOUR AND METABOLISM LAB

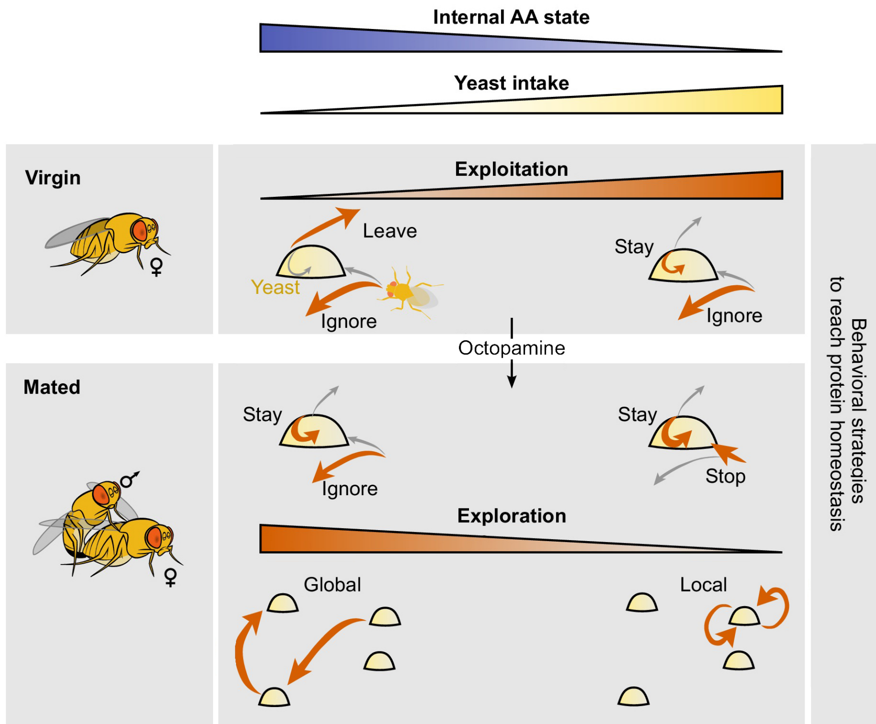
LAB MEMBERS

POSTDOCTORAL RESEARCHERS
1. Kathrin Steck
2. Pavel Itskov
3. Zita Santos

PHD STUDENTS
4. Dennis Goldschmidt
5. Patrícia Francisco
6. Samantha Herbert
7. Samuel Walker
8. Verónica Corrales

RESEARCH TECHNICIANS
9. Margarida Anjos
10. Celia Baltazar
11. José Maria Moreira

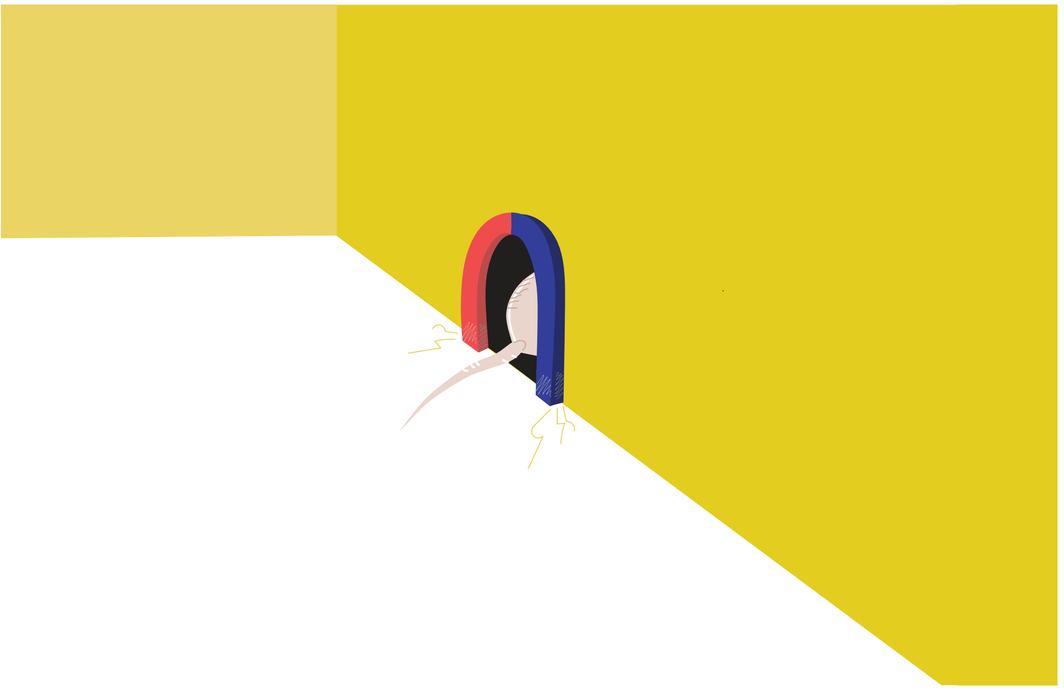
LAB MANAGER
12. Ana Paula Elias



Model of behavioural strategies modulated by internal amino acids state

We propose a model in which virgin flies with high internal levels of AAs display low intake mostly ignore yeast patches upon encounter and have a high probability of leaving the yeast patch upon stopping at it. Internal AA levels decrease as a consequence of poor diets which induce a change in the leaving decision, inducing increased yeast intake. Octopamine mediates the postmating changes in the foraging decisions of stopping at the yeast patch and leaving it upon encounter. As the internal AA levels decrease in mated females, their exploration patterns switch from global exploration to local exploration and multiple returns to the same yeast patch.

How do experience and learning shape brain activity and structure, as revealed by MRI?



Principal Investigator
NOAM SHEMESH
Joined CF in 2014

NEUROPLASTICITY AND NEURAL ACTIVITY LAB

NO ONE EVER RECORDS FROM THE SAME BRAIN TWICE

When the Greek Philosopher Heraclitus spoke about how change is central to the universe, coining the phrase "no one ever steps into the same river twice", one wonders if he could have foreseen the implications his words would have on the human brain. Throughout normal development, experience and learning, or injury and disease, our brain's activity and structure are always in motion. So much so that one can almost even say that no one ever records from the same brain twice. How do these different processes influence the brain's functionality and structure over time?

Scientific Approach

To find the "missing link" between behaviour and changes on the molecular or cellular level, the Neuroplasticity and Neural Activity lab develops pioneering functional magnetic resonance imaging (fMRI) techniques. These techniques are non-invasive, powerful tools for studying various neuroscience and biomedical questions. Current fMRI methods work by performing indirect measures of neural activity by following accompanying changes in blood volume and oxygenation level. However, changes in blood flow, in addition to being an indirect measure, occur over a timescale of seconds, while neural activity occurs within a fraction of a single second. This difference in timescale points out an obvious limitation of current fMRI techniques – they are too slow to resolve many important processes in the brain. To address these issues, the team's first steps, for which they have recently received support from the European Research Council, have been focused on developing novel techniques that harness the power and versatility of MRI to perform direct measurements of neural activity on a much faster timescale. For instance, the team harnesses ultrahigh magnetic fields to image the dynamics of cell swellings (which are coupled with neural activity), as well as neurotransmitter release in the brain. These various measurements are performed *in vivo* using state-of-the-art 9.4T and 16.4T scanners, in both anesthetised and behaving rodents.

MAIN INTERESTS:
Direct functional MRI based on cell swellings and neurotransmitter release

METHODS:
Functional Magnetic Resonance Imaging (fMRI), Optogenetics, Behaviour

MODEL /AREA OF FOCUS:
Rodents / Whole Brain

NEUROPLASTICITY AND NEURAL ACTIVITY LAB

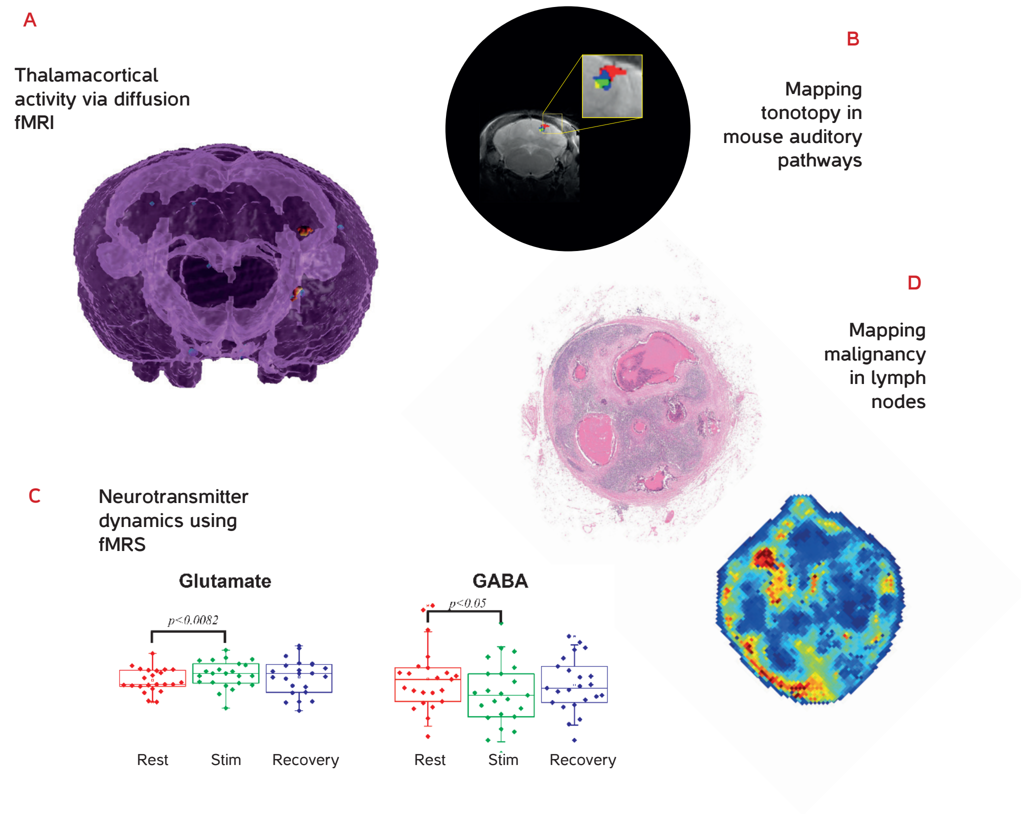
LAB MEMBERS

POSTDOCTORAL RESEARCHERS
1. Cristina Chavarrías
2. Daniel Nunes
3. Ekaterina Vinnik
4. Miguel Mondragão
5. Andrada Ianus
6. Tal Shemesh

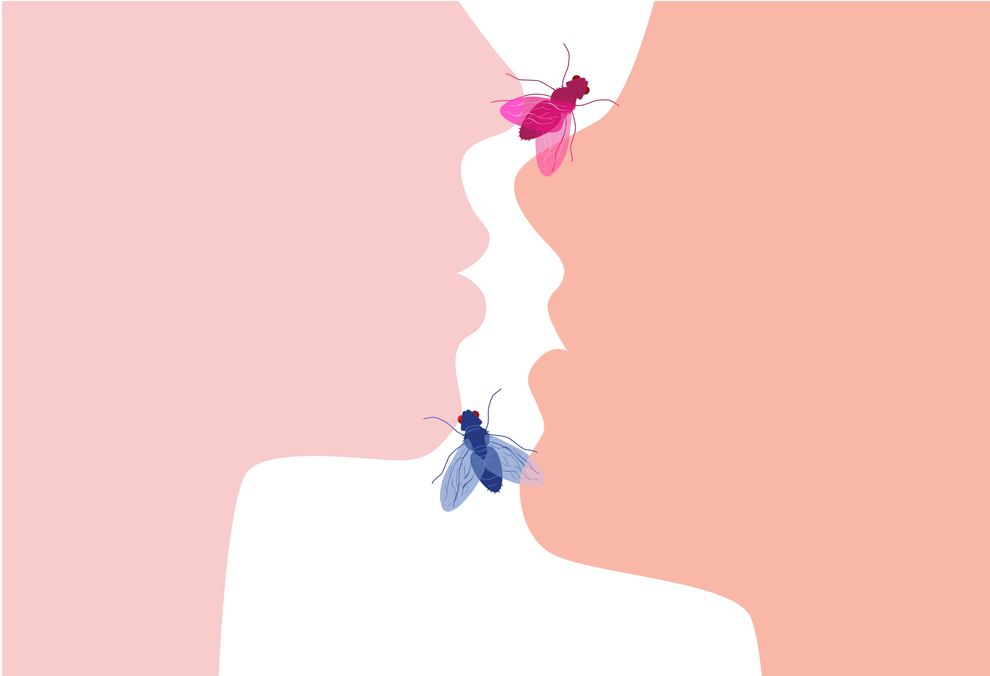
RESEARCH FELLOW
7. Sónia Gonçalves

PHD STUDENT
8. Madalena Fonseca

RESEARCH TECHNICIANS
9. Frederico Severo
10. Rita Gil
11. Teresa Serradas Duarte
12. Guilherme Freches



New ways of mapping brain activity as well as infiltration of malignant cells into lymph nodes
Images were acquired at 9.4 and 16.4T.



How does the brain control innate behaviours such as courtship?

Principal Investigator
LUÍSA VASCONCELOS
Joined CF in 2011

INNATE BEHAVIOUR LAB

WHEN INSTINCTS TAKE OVER

You are walking down the street with your stomach rumbling when you suddenly catch a whiff of a delicious smell. Without giving it a second thought, you decide to follow it, making a few wrong turns until you find yourself in a nice bakery. This behaviour, common to humans and other animals, is called foraging, the active seeking of food. It is actually only one example of a group of behaviours defined as instinctive, or innate. These behaviours do not require learning, nor experience, they are often involuntary and can occur in individuals even without their awareness. Other well-known examples of innate behaviours include nest-building and courtship. Fortunately, unlike other behaviours such as decision-making, the neural circuits that underlie innate behaviours are hardwired, which means that they are invariant from animal to animal. This fact makes these behaviours an excellent case study in neuroscience, where the neural processes involved can be mapped out from sensory input to motor output.

Scientific Approach

To dig down into the neural circuitry of innate behaviour, the Innate Behaviour lab focuses on two main behaviours – the relatively simple avoidance of a repulsive odour and the more intricate courtship behaviour. Both are studied in the fruit fly *Drosophila melanogaster*, a powerful model system that offers a wide range of advanced techniques. These include genetic tools and manipulations to help to identify which neurons are involved in specific behaviours and optogenetic tools to monitor the activity of neurons by using changes in calcium level, for instance, a proxy for neural activity. Together, these tools enable the researchers to pin down the anatomical and functional components of neural circuits. The team uses these tools together with highly detailed video monitoring to establish the most precise relationship between behaviour and neural activity. The team studies different brain areas to understand each of these behaviours. Specifically, to study odour avoidance, the team investigates how two higher order olfactory centres of the fly's brain interact to generate escape behaviour. Studying the more complex courtship behaviour, however, may lead to any part of the brain, turning it into a very exciting journey.

MAIN INTERESTS:
Identification of the neural circuits and mechanisms that control innate, or instinctive, behaviours

METHODS:
Optogenetics, Imaging, Behaviour, Genetics

MODEL /AREA OF FOCUS:
Fruit Fly / Whole Brain

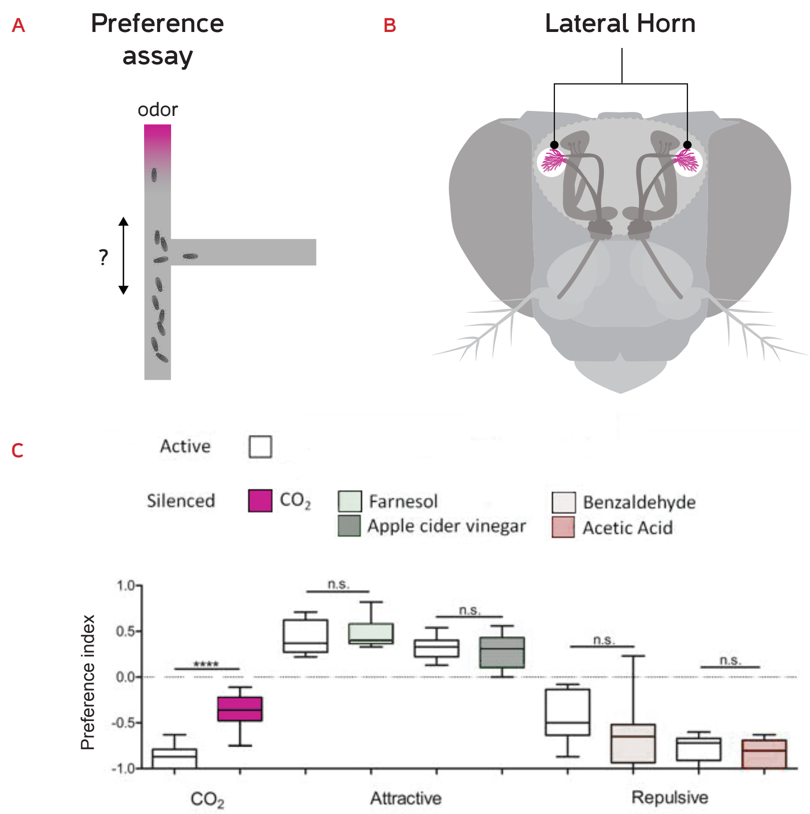
INNATE BEHAVIOUR LAB

LAB MEMBERS

POSTDOCTORAL RESEARCHERS
1. Cecilia Mezzera
2. Márcia Aranha
3. Nélia Varela

PHD STUDENTS
4. Cristina Ferreira
5. Eliane Ochôa Arez
6. Miguel Gaspar

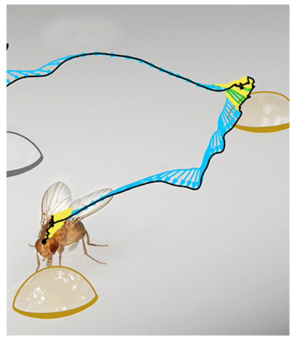
RESEARCH TECHNICIANS
7. Hugo Cachitas
8. Sophie Dias



Line 1 Lateral Horn neurons are specifically involved in the response to carbon dioxide

Publications Highlights

THE DISCOVERIES RESULTING FROM THE WORK OF CR RESEARCHERS ARE REGULARLY PUBLISHED IN HIGH-IMPACT JOURNALS, MIRRORING THE SIGNIFICANT POTENTIAL REACH OF THE RESEARCH DONE BY CR INVESTIGATORS.

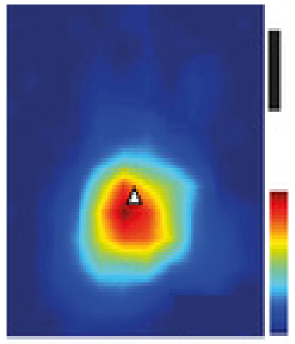


Behaviour And Metabolism Lab

Hungry for adventure

Using a highly precise computerised visualisation technique developed in the lab, this study revealed not only that flies' food choices are influenced by their physiological needs, but that their willingness to take risks does as well.

Corrales-Carvajal VM, Faisal AA, Ribeiro C. (2016). Internal states drive nutrient homeostasis by modulating exploration-exploitation trade-off. Elife. 2016 Oct 22;5. pie: e19920.



Cortical Circuits Lab

Cortical neural circuitry mapped with unprecedented detail

Thanks to a novel technique developed at the lab, the connectivity of individual axons with remote brain structures was mapped, thereby revealing the organization of neural circuitry in the mammalian visual system with unprecedented detail.

Morgenstern NA, Bourg J, Petreanu L. (2016) Multilaminar networks of cortical neurons integrate common inputs from sensory thalamus Nat. Neurosci. 19(8):1034-1040.

Learning Lab

Controlling subjective time judgement with dopamine

Why is it that time flies when you are having fun, but seems to drag endlessly when you are bored? In this study, the team found not only that the activity of a group of dopamine neurons in the brain is correlated with subjective time estimation in mice, but also that selective activation of these neurons was sufficient to cause changes in the animals' judgment of time.

Soares S, Atallah BV, Paton JJ. (2016). Midbrain dopamine neurons control judgment of time. Science. 354(6317):1273-1277. data streams. Frontiers in Neuroinformatics. 9:7.

Publications

RESEARCH ARTICLES

Barrett DGT, Deneve S, Machens CK (2016). Optimal compensation for neuron loss. eLife 5:e12454.

Bischof HJ, Eckmeier D, Keary N, Löwel S, Mayer U, Michael N (2016) Multiple Visual Field Representations in the Visual Wulst of a Laterally Eyed Bird, the Zebra Finch (Taeniopygia guttata) PLoS ONE. 11(5):e0154927.

Clément G, Loureiro N, Sousa D, Zandvliet A. (2016) Perception of Egocentric Distance during Gravitational Changes in Parabolic Flight. PLoS One. 11(7):e0159422.

Corrales-Carvajal VM, Faisal AA, Ribeiro C. (2016). Internal states drive nutrient homeostasis by modulating exploration-exploitation trade-off. Elife. 2016 Oct 22;5. pii: e19920.

Cotovio G, Oliveira-Maia AJ. (2016). Hypomania induced by a Garcinia cambogia supplement. Aust N Z J Psychiatry. pii: 0004867416667827.

de Lacerda TC, Costa-Silva B, Giudice FS, Dias MV, de Oliveira GP, Teixeira BL1, Dos Santos TG, Martins VR. (2016) Prion protein binding to HOP modulates the migration and invasion of colorectal cancer cells. Clin Exp Metastasis. 33(5):441-51.

Duteil M, Pope EC, Pérez-Escudero A, de Polavieja GG, Fürtbauer I, Brown MR, King AJ. (2016). European sea bass show behavioural resilience to near-future ocean acidification. R Soc Open Sci. 3(11):160656.

Farias M, Certal AC. (2016). Different Feeds and Feeding Regimens have an Impact on Zebrafish Larval Rearing and Breeding Performance. Int J Marine Biol Res. 1(1):1-8.

Fujiwara T, Cruz TL, Bohnslav JP, Chiappe ME. (2016). A faithful internal representation of walking movements in the Drosophila visual system. Nat Neurosci. 20(1):72-81.

Gradari S, Pérez-Dómper P, Butler RG, Martinez-Cué C, de Polavieja GG, Trejo JL. (2016) The relationship between behaviour acquisition and persistence abilities: Involvement of adult hippocampal neurogenesis. Hippocampus. 26(7):857-74.

Ghania MU, Kanika SD, Argunsah AO, Hobbiss AF, Israely I, Ünay D, Tasdizen T, Cetin M. (2016). Dendritic spine classification using shape and appearance features based on two-photon microscopy. J Neurosci Methods. 279:13-21.

Gremel CM, Chancey JH, Atwood BK, Luo G, Neve R, Ramakrishnan C, Deisseroth K, Lovinger DM, Costa RM. (2016). Endocannabinoid Modulation of Orbitostriatal Circuits Gates Habit Formation. Neuron. 90(6):1312-24.

Hansen B, Shemesh N, Jespersen SN. (2016). Fast imaging of mean, axial and radial diffusion kurtosis. Neuroimage.142:381-393.

Ibiza S, Garcia-Cassani B, Ribeiro H, Carvalho T, Almeida L, Marques R, Misic AM, Bartow-McKenney C, Larson DM, Pavan WJ, Eberl G, Grice EA, Veiga-Fernandes H. (2016). Glial-cell-derived neuroregulators control type 3 innate lymphoid cells and gut defence. Nature. 535(7612):440–443.

Kobak D, Brendel W, Constantinidis C, Feierstein CE, Kepecs A, Mainen ZF, Romo R, Qi XL, Uchida N, Machens CK. (2016). Demixed principal component analysis of neural population data. eLife. pii: e10989.

Lanuș A, Shemesh N, Alexander DC, Drobnjak I. (2016). Double oscillating diffusion encoding and sensitivity to microscopic anisotropy. Magn Reson Med. doi: 10.1002/mrm.26393.

Levayer R, Dupont C, Moreno E. (2016). Tissue Crowding Induces Caspase-Dependent Competition for Space. Curr Biol. 26(5):670-7.

Lottem E, Lörincz ML, Mainen ZF. (2016) Optogenetic Activation of Dorsal Raphe Serotonin Neurons Rapidly Inhibits Spontaneous But Not Odor-Evoked Activity in Olfactory Cortex. J. Neurosci. 36(1):7-18.

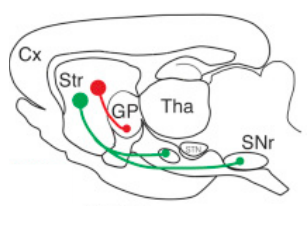
Lu R, Sun W, Liang Y, Kerlin A, Bierfeld J, Seelig J, Wilson DE, SchollB, Mohar B, Tanimoto M, Koyama M, Fitzpatrick D, Orger MB, Ji N. (2016). Video-rate volumetric functional imaging of the brain at synaptic resolution. bioRxiv 058495; doi: https://doi.org/10.1101/058495.

Martins S, Monteiro JF, Vito M, Weintraub D, Almeida J, Certal AC. (2016). Toward an Integrated Zebrafish Health Management Program Supporting Cancer and Neuroscience Research. Zebrafish. 13(S1): S-47-S-55.

Morgenstern NA, Bourg J, Petreanu L. (2016) Multilaminar networks of cortical neurons integrate common inputs from sensory thalamus. Nat. Neurosci. 19(8):1034-1040.

Oliveira-Maia A, Mendonça C, Camacho M, Pessoa MJ, Gago J. (2016). The Mental Health Recovery Measure Can Be Used to Assess Aspects of Both Customer-Based and Service-Based Recovery in the Context of Severe Mental Illness. Front Psychol. 7:1679.

* Equal contribution

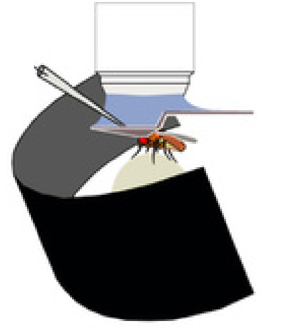


Neurobiology of Action Lab

Breaking the dogma

Though classically thought to work against each other, this study shows that the two basal ganglia pathways that are known to be crucial for performing actions, actually complement each other. Specifically, the role of the direct pathway seems to be to sustain action, while the role of the indirect pathway appears to be to allow – or prevent – switching from one action to another.

Tecuapetla F, Jin X, Lima SQ, Costa RM. (2016). Complementary Contributions of Striatal Projection Pathways to Action Initiation and Execution. Cell. 2016 Jul 28;166(3):703-15.

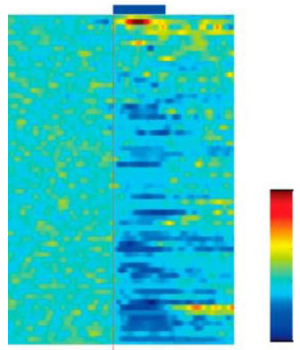


Sensorimotor Integration Lab

What is information about movement doing in the visual part of the brain?

This study revealed that a group of visual interneurons, previously thought to be purely sensory, also encodes information independent of vision about the fly's speed and direction of walking, showing that successful locomotion involves the representation of motor-related signals in sensory regions of the fly brain.

Terufumi Fujiwara, Tomás L Cruz, James P. Bohnslav, and M Eugenia Chiappe (2016) A faithful internal representation of walking movements in the Drosophila visual system. Nat Neurosci. ;20(1):72-81

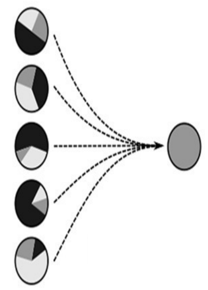


Systems Neuroscience Lab

How does Serotonin influence sensory processing?

This study shows that serotonin inhibits the spontaneous activity of neurons in the olfactory cortex on a rapid timescale, but leaves responses to ongoing sensory inputs unaffected. These results identify a new role for serotonergic modulation in rapidly changing the balance between different sources of neural activity in sensory systems.

Lottem E', Lörincz ML', Mainen ZF. (2016) Optogenetic Activation of Dorsal Raphe Serotonin Neurons Rapidly Inhibits Spontaneous But Not Odor-Evoked Activity in Olfactory Cortex. J. Neurosci. 36 (1):7-18.



Theoretical Neuroscience Lab

Can't see the forest for the trees? Try this mathematical steamroller!

In this study, the team developed a new mathematical technique that allows researchers to decompose the activity of a population of neurons into its individual bits and pieces. This way, different types of information that are coded by the population can be properly visualised on a single sheet of paper.

Kobak D, Brendel W, Constantinidis C, Feierstein CE, Kepecs A, Mainen ZF, Romo R, Qi XL, Uchida N, Machens CK. (2016). Demixed principal component analysis of neural population data. eLife 2016 (5), e10989.

Publications

Orger MB, Portugues R. (2016) Correlating Whole Brain Neural Activity with Behaviour in Head-Fixed Larval Zebrafish. Methods Mol Biol. 1451:307-20.

Soares S, Atallah BV, Paton JJ. (2016). Midbrain dopamine neurons control judgment of time. Science. 354(6317):1273-1277.

Tecuapetla F, Jin X, Lima SQ, Costa RM. (2016). Complementary Contributions of Striatal Projection Pathways to Action Initiation and Execution. Cell. 2016 Jul 28;166(3):703-15.

Tian J, Huang R, Cohen JY, Osakada F, Kobak D, Machens CK, Callaway EM, Uchida N, Watabe-Uchida M (2016). Distributed and mixed information in monosynaptic inputs to dopamine neurons. Neuron 91(6):1374-1389.

Vicente AM, Galvão-Ferreira P, Tecuapetla F, Costa RM. (2016). Direct and indirect dorsolateral striatum pathways reinforce different action strategies. Curr Biol. 26(7):R267-9.

Zhang Q, Gao X, Li C, Feliciano C, Wang D, Zhou D, Mei Y, Monteiro P, Anand M, Itohara S, Dong X, Fu Z, Feng G. (2016). Impaired Dendritic Development and Memory in Sorbs2 Knock-Out Mice. J Neurosci. 36 (7):2247-2260.

REVIEWS

Barahona-Corrêa JB, Filipe CN. (2016). A Concise History of Asperger Syndrome: The Short Reign of a Troublesome Diagnosis. Front Psychol. 6:2024.

Deneve S, Machens CK. (2016). Efficient codes and balanced networks. Nat Neurosci. 19(3):375-382.

Gomez-Marin A, Mainen ZF. (2016). Expanding perspectives on cognition in humans, animals, and machines. Curr Opin Neurobiol. 37:85-91.

Levayer R, Moreno E. (2016). How to be in a good shape? The influence of clone morphology on cell competition. Commun Integr Biol. 9(1):e1102806.

Merino MM, Levayer R, Moreno E. (2016). Survival of the Fittest: Essential Roles of Cell Competition in Development, Aging, and Cancer. Trends Cell Biol. 26(10):776-88.

Orger MB. (2016). The Cellular Organization of Zebrafish Visuomotor Circuits. Curr Biol. 26(9):R377-85.

Peinado H, Zhang H*, Matei IR*, Costa-Silva B, Hoshino A, Rodrigues G, Psaila B, Kaplan RN, Bromberg J, Kang Y, Bissell MJ, Cox TR, Giaccia AJ, Erler JT, Hiratsuka S, Ghajar CM, Lyden D. (2016). Pre-metastatic niches: organ-specific homes for metastases. Nature Reviews Cancer, Accepted for publication (2016).*

Pereira AG, Moita MA. (2016). Is there anybody out there? Neural circuits of threat detection in vertebrates. Curr Opin Neurobiol. 41:179-187.

Shemesh N, Jespersen SN*, Alexander DC, Cohen Y, Drobnjak I, Dyrby TB, Finsterbusch J, Koch MA, Kuder T, Laun F, Lawrenz M, Lundell H, Mitra PP, Nilsson M, Özarslan E, Topgaard D, Westin CF. (2017). Conventions and nomenclature for double diffusion encoding NMR and MRI. Magn Reson Med. 75(1):82-7. doi: 10.1002/mrm.25901.*

Veiga-Fernandes H, Mucida D. (2016) Neuro-Immune Interactions at Barrier Surfaces. Cell. 165(4):801-11.

BOOK CHAPTERS

Silvério FJ, Certal AC, Mão de Ferro C, Monteiro JF, Almeida Cruz J, Ribeiro R, Silva JN. (2016). Automatic System for Zebrafish Counting in Fish Facility Tanks. Image Analysis and Recognition. Volume 9730 of the series Lecture Notes in Computer Science: 774-782.

COMMENTS

Levitt P, Carey M, Ramirez S, Dzirasa K, Di Luca M. (2016). Supporting the next generation of neuroscientists. Neuron 92:559-560.

Renninger SL, Orger MB. (2016). A choice motif. eLife. 5. pii: e19351.

Schwabe L, López-Bendito G, Ribeiro C. (2016). Getting published: how to write a successful neuroscience paper. Eur J Neurosci. 43(8):992-6.

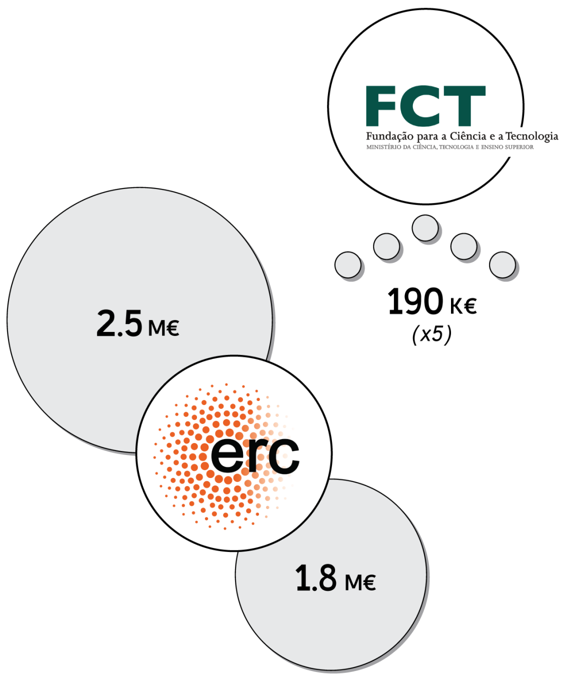
PATENTS

Cohen Y, Shemesh Noam. Magnetic resonance analysis using a plurality of pairs of bipolar gradient pulses. U.S. Patent 9,494,665 B2. November 15, 2016.

* Equal contribution

Funding Highlights

CR IS SUPPORTED BY FUNDS PROVIDED BY THE CHAMPALIMAUD FOUNDATION AND BY EXTERNAL FUNDS FROM A DIVERSE GROUP OF NATIONAL AND INTERNATIONAL ORGANISATIONS.



FCT
Fundação para a Ciência e a Tecnologia

Five Scientific research and technological development Projects were awarded to CR investigators in 2016, each for the sum of 190K euros for a duration of three years:

Awarded to Rui Costa and Inbal Israely:

Determining the basal ganglia circuits involved in repetitive behaviours in Autism Spectrum Disorders.

Awarded to Susana Lima:

Female socio-sexual behaviour: role of hypothalamic neuronal activity across the reproductive cycle.

Awarded to Michael Orger:

The neural circuit basis of oculomotor behaviour in zebrafish.

Awarded to Gonzalo de Polavieja:

Decision-making in animal groups: a multidisciplinary approach to understand how social information is processed.

Awarded to Noam Shemesh:

Mapping specific neural activity by coupling ultrahigh field functional-MRI, optogenetics, and calcium recordings.

ERC
European Research Council

The funding of two European Research Council grants began in 2016.

Funding 2.5 M €
Awarded to Zachary Mainen

The first, titled Modulation of cortical circuits and predictive neural coding by serotonin, was awarded to Zachary Mainen, with a total sum of 2.5M euros over a duration of 5 years. This ERC Advanced Grant will be dedicated to studying how serotonin influences the way we perceive the world and consequently our behaviour.

Funding 1.8 M €
Awarded to Noam Shemesh

The second, titled Sensing activity-induced cell swellings and ensuing neurotransmitter releases for in-vivo functional imaging sans hemodynamics, was awarded to Noam Shemesh, with a total sum of 1.8M euros over a duration of 5 years. Dr. Shemesh was awarded this ERC Starting Grant to establish cutting edge Magnetic Resonance Imaging methodologies that will provide novel insights into neural function during health and disease.

The following CR Researchers also hold a currently active ERC grant: Marta Moita, Megan Carey, Rui Costa and Eduardo Moreno.

EMBO
European Molecular Biology Organization

Three postdoctoral researchers at CR were awarded a prestigious EMBO long-term fellowship in 2016.

Fanny Cazettes, a researcher in the lab of Zachary Mainen, received the fellowship to study Neuromodulation of cortical Representation of policy uncertainty.

Hanne Stensola's project titled "Integration of prior expectations with sensory evidence in the laminar auditory cortical circuit", will be pursued in the lab of Alfonso Renart.

Paolo Botta, who works in the lab of Rui Costa, received this fellowship for the project "Dissecting amygdalo-striatal circuits for exploration".

Projects Announced / Started in 2016

European Research Council

Mainen, Zachary. Modulation of cortical circuits and predictive neural coding by serotonin. ERC Advanced Grant. (Started 2016).

Shemesh, Noam. Sensing activity-induced cell swellings and ensuing neurotransmitter releases for in-vivo functional imaging sans hemodynamics. ERC Starting Grant. (Started 2016).

Horizon 2020, ERC-POC

Costa, Rui. Stable Brain-Machine control via a learnable standalone interface. ERC Proof of Concept Grant. (Started 2016).

Horizon 2020, HBP-SGA1

Costa, Rui. Cognitive and Systems Neuroscience Subproject . (Started 2016).

Fundação Bial

Paton, Joe. How do dopamine neurons and striatal populations interact during decision-making? Bial Science Research Grant. (Announced 2016).

Ribeiro, Carlos. Harnessing the power of closed-loop neuronal control to identify the circuit basis of decision making. Bial Science Research Grant. (Announced 2016).

Fundação Para a Ciência e a Tecnologia

Costa, Rui & Israely, Inbal. Determining the basal ganglia circuits involved in repetitive behaviours in Autism Spectrum Disorders. Scientific research and technological development Project. (Started 2016).

Lima, Susana. Female socio-sexual behaviour: role of hypothalamic neuronal activity across the reproductive cycle. Scientific research and technological development Project. (Started 2016).

Orger, Michael. The neural circuit basis of oculomotor behaviour in zebrafish. Scientific research and technological development Project. (Started 2016).

Polavieja, Gonzalo. Decision-making in animal groups: a multidisciplinary approach to understand how social information is processed. Scientific research and technological development Project. (Started 2016).

Shemesh, Noam. Mapping specific neural activity by coupling ultrahigh field functional-MRI, optogenetics, and calcium recordings. Scientific research and technological development Project. (Started 2016).

National Institutes of Health

Machens, Christian. computational and circuit mechanisms for information transmission in the brain. Brain Initiative Grant. (Started 2016).

Portugal 2020

Costa, Rui (partner). Sondas neuronais dotadas com interação elétrica, ótica e comunicação sem fios para controlo de neurónios-alvo. Projecto de I&DT em Co-promoção. (Started 2016).

Ciência Viva

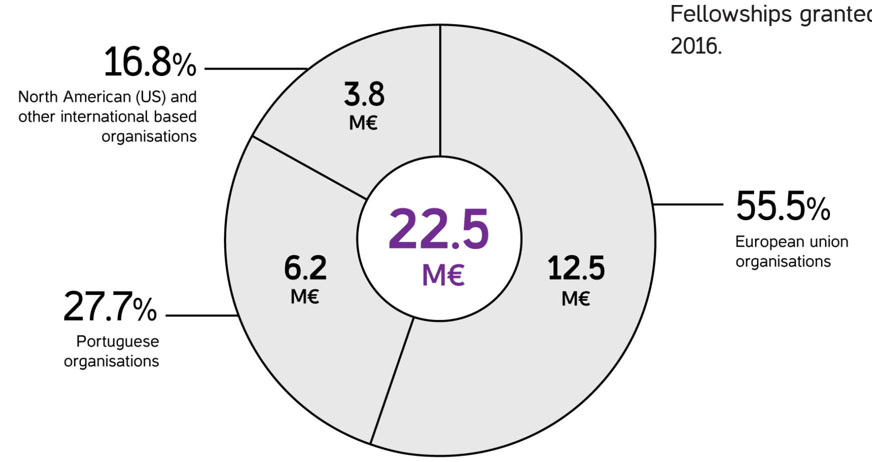
Ramos, Catarina. Ciência Viva no Laboratório-Ocupação Cientifica de Jovens nas férias (edição 2016). (Started 2016).

ONR Global

Ribeiro, Carlos. 5th Champalimaud Neuroscience Symposium. Office of Naval Research Grant. (Started 2016).

External Funding: Projects & Fellowships Active in 2016

This diagram represents the sum off all external funds actively running at CR during 2016. These include Projects and Fellowships granted between 2012 and 2016.



Fellowships Announced / Started in 2016

AXA Research Fund

Cazettes, Fanny. Neural Representations of Policy uncertainty underlying adaptative behaviour. Axa research Fund Post-doctoral Fellowship. (Started 2016).

European Molecular Biology Organization (EMBO)

Botta, Paolo. Dissecting amygdalo-striatal circuites for exploration. EMBO Long Term Fellowship. (Started 2016).

Cazettes, Fanny. Neuromodulation of cortical Representation of policy uncertainty. EMBO Long Term Fellowship. (Started 2016).

Stensola, Hanne. Integration of prior expectations with sensory evidence in the laminar auditory cortical circuit. EMBO Long Term Fellowship. (Started 2016).

Fundação Para a Ciência e a Tecnologia (FCT)

INDP Class of 2015: Basma Husain, Baylor Brangers, Dennis Goldschmidt, Marta Iglesias, Mauricio Toro, Patrícia Francisco, Rodrigo Dias, Severin Berger. (Started 2016).

Pritchett, Dominique (with Carey, Megan). Optogenetic circuit dissection of neural instructive signals for cerebellum-dependent learning. Postdoctoral Fellowship. (Started 2016).

Japan Society for the Promotion of Science

Fujiwara, Terufumi. Neural basis of self-movement estimation during walking. (Announced 2016).

Erasmus Medical Center

Marcelo, Ivo. Neurobiology of social cognition. (started 2016).

Education Highlights

SINCE THE BEGINNING, THE CR HAS REGARDED EDUCATING FUTURE NEUROSCIENTISTS AS ONE OF ITS MAIN OBJECTIVES. TO THIS END, THE CNP HAS BEEN DEDICATING CONSIDERABLE EFFORTS TO THE DEVELOPMENT AND IMPLEMENTATION OF OUTSTANDING EDUCATIONAL PROGRAMMES, ADVANCED COURSES AND WORKSHOPS.

INDP
International Neuroscience Doctoral Programme

INDP Director: Alfonso Renart

The INDP aims at providing students with a broad and integrative education in neuroscience with a focus on the neuronal and circuit basis of behaviour. A main goal of the programme is to foster and encourage active participation, independence and critical thinking on the part of the students.

During the first year of this 4-year programme, students attend courses that cover basic topics in contemporary neuroscience. The courses have a strong practical component, which includes a variety of experimental preparations. During this year, students also perform lab rotations, which allow them to familiarise themselves with the research done in the different labs and help them with selecting the lab where they will conduct their doctoral research during the next three years.

Theses

Feb 3
PhD awarded to: Robert Hinz
Title: Analysis of Social Behaviour in Zebrafish.
Thesis advisor: Gonzalo de Polavieja, CR.

Feb 16
MSc awarded to: Gonçalo Figueira
Title: A ladder paradigm for studying locomotor coordination in mice.
Thesis advisor: Megan Carey, CR.

Feb 23
PhD awarded to: Pedro Ferreira
Title: Behavioural and transcriptional plasticity in striatal circuits: From optogenetics to epigenetics.
Thesis Advisor: Rui Costa, CR.

Mar 10
PhD awarded to: Gustavo Mello
Title: Neural and Behavioural Mechanisms of Interval Timing in the Striatum.
Thesis Advisor: Joe Paton, CR.

Mar 28
PhD awarded to: Mafalda Vicente
Title: Neuronal circuits underlying learning of competing action strategies.
Thesis Advisor: Rui Costa, CR.

May 5
PhD awarded to: Thiago Gouvêa
Title: Striatal dynamics represent subjective time: A psychophysical study of the neural representation of time by striatal populations.
Thesis Advisor: Joe Paton, CR.

May 9
PhD awarded to: João Marques
Title: Density Valley Clustering Reveals New Swim Types of the Zebrafish Larvae.
Thesis Advisor: Michael Orger, CR.

May 17
PhD awarded to: Ana Rita Fonseca
Title: Pombal's maze: a novel decision-making paradigm.
Thesis Advisor: Zachary Mainen, CR.

Jun 23
PhD awarded to: Mariana Cardoso
Title: Endogenous and exogenous hemodynamic signals in primary visual cortex of alert non-human primates.
Thesis Advisor: Aniruddha Das, Columbia University.

Jul 8
PhD awarded to: Margarida Agrochão.
Title: The visual Superior Colliculus in awake rats: field potentials and single-cell response properties.
Thesis Advisor: Markus Meister, California Institute of Technology.

Jul 11
PhD awarded to: Diogo Peixoto.
Title: Single trial correlates of decision-making in dorsal premotor and primary motor cortices.
Thesis Advisor: Bill Newsome, Stanford University School of Medicine.

Jul 12
PhD awarded to: Anna Hobbiss.
Title: Structural scaling and threshold modulation of dendritic spines driven by homeostatic plasticity.
Thesis Advisor: Inbal Israely, CR.

Jul 15
MSc awarded to: Jullien Fiorilli.
Title: Procedures towards auditory working memory tasks in head-fixed mice.
Thesis Advisor: Alfonso Renart, CR.

Jul 20
PhD awarded to: Ali Ozgur Argunsah.
Title: Activity dynamics lead to diverse structural plasticity at single dendritic spines.
Thesis Advisor: Inbal Israely, CR.

Sep 13
PhD awarded to: Raquel Patricia de Sousa Abreu
Title: PreBötzinger Complex SST+ neurons modulate breathing rhythm and pattern.
Thesis Advisor: Jack L. Feldman, University of California, Los Angeles.

Sep 15
PhD awarded to: Scott Rennie
Title: Rats Hunt Stag: Integration of social and economic information drives cooperation in a collective decision making task.
Thesis Advisor: Marta Moita, CR.

November 8, 2016
MSc awarded to: Shane Beato
Title: Characterization of Novel High Density Neurophysiological Probes using Optical Recordings of Neural Activity.
Thesis Advisor: Leopoldo Petreanu, CR.

Nov 10
MSc awarded to: André Filipe Rodrigues Marques
Title: Neural encoding of motion visual cues in horizontally sensitive neurons of Drosophila.
Thesis Advisor: Eugenia Chiappe, CR.

Nov 11
MSc awarded to: Guilherme Freches
Title: Mapping the tonotopy in the mice brain at UHF MRI: Design and application of an auditory stimulation setup for functional studies.
Thesis Advisor: Noam Shemesh, CR.

Nov 21
PhD awarded to: David Nunes Raposo
Title: The role of posterior parietal cortex in multisensory decision-making.
Thesis Advisor: Anne Churchland, Cold Spring Harbor Laboratory.

Nov 24
MSc awarded to: Teresa Margarida Figueiredo Silva
Title: Characterization of mating behaviour of the female fruit fly using machine vision.
Thesis Advisor: Maria Luisa Vasconcelos, CR.

Nov 29
MSc awarded to: Diogo Matias
Title: Neuronal mechanisms underlying sex hormone dependent behaviour modulation.
Thesis Advisor: Susana Lima, CR.

Nov 29
PhD awarded to: Verónica Corrales-Carvajal
Title: Tracking nutrient decisions in Drosophila melanogaster.
Thesis Advisor: Carlos Ribeiro, CR.

Dec 7
PhD awarded to: Pedro Garcia Da Silva
Title: Task Related Representations in Long Range Feedback.
Thesis Advisor: Dinu F. Albeanu, Cold Spring Harbor Laboratory.

Dec 9
PhD awarded to: Gonçalo Lopes
Title: A Robust Role for Motor Cortex.
Thesis Advisor: Joe Paton (CR), Adam Kampff (University College London).

Dec 19
PhD awarded to: Ana Sofia Machado
Title: LocoMouse: a novel system for studying the role of cerebellum in gait coordination.
Thesis Advisor: Megan Carey, CR.

Dec 20
PhD awarded to: Sevinç Mutlu.
Title: Anatomical and functional mapping of stratal circuits controlling licking.
Thesis Advisor: Rui Costa, CR.

CAJAL Advanced Neuroscience Training Programme

The CAJAL Advanced Neuroscience Training programme consists of 4 yearly courses, 2 held at Champalimaud Centre for the Unknown in Lisbon and 2 in Bordeaux Neurocampus. These two institutes were chosen to be the first centres in Europe that will host recurring neuroscience training courses, following a model that has been successfully running in the US for decades.

CAJAL Advanced Course: Advanced Course in Behaviour and Neural Systems

July 10 - 31, 2016

Course Directors: Adam Kampff (Sainsbury Wellcome Centre, University College London, UK), Zachary Mainen, (CR) and Florian Engert (Harvard University, USA).

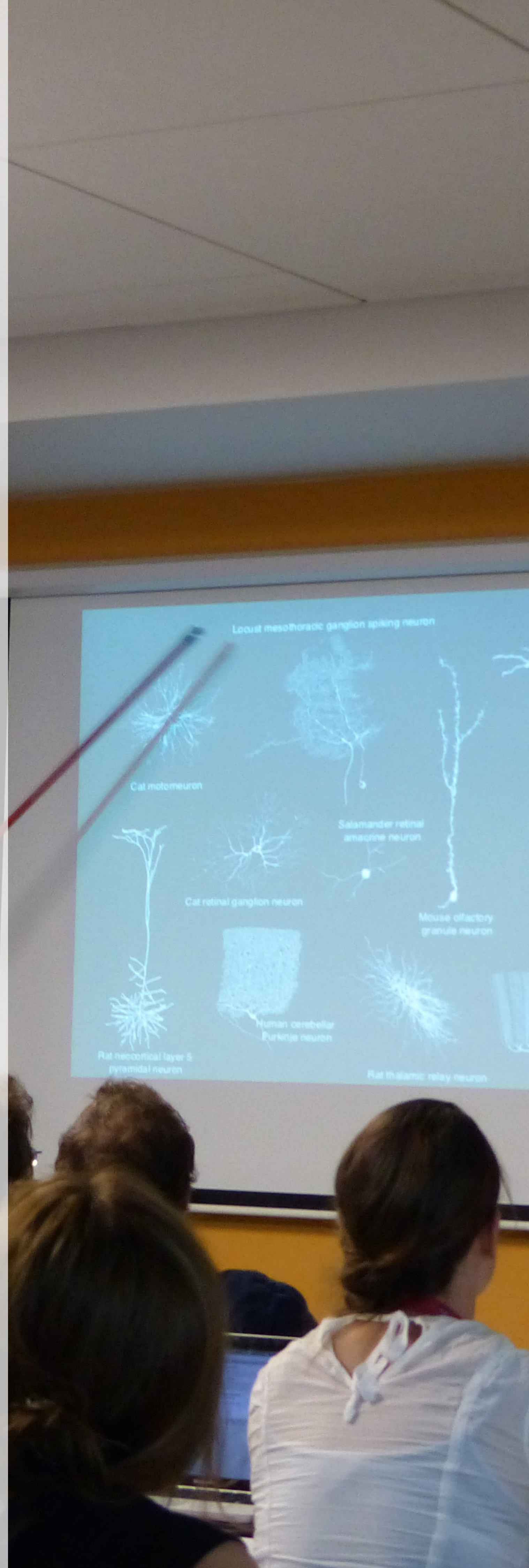
This 3-week course was a practical "hands-on" introduction to advanced methods in behavioural neuroscience and provided sufficient background such that all participants will were able to establish these techniques in their home laboratories. Popular model organisms (rodents, Drosophila, and zebrafish) were used to demonstrate how modern technology (e.g. video tracking, virtual reality, automation, etc.) could be combined with traditional behavioural approaches to perform truly innovative neuroscience investigations.

CAJAL Advanced Course: Computational Neuroscience

August 07-27, 2016

Course Directors: Christian Machens (CNP), Gilles Laurent (Max Planck Institute for Brain Research, Frankfurt, Germany), Mate Lengyel (Cambridge University, UK).

Computational Neuroscience is a rapidly evolving field whose methods and techniques are critical for understanding and modeling the brain, and also for designing and interpreting experiments. Mathematical modeling is one of the few tools available to cut through the vast complexity of neurobiological systems and their many interacting elements. This three-week school taught the central ideas, methods, and practice of modern computational neuroscience through a combination of lectures and hands-on project work.



Courses, Workshops & Events
Highlights

TO COMPLEMENT RESEARCH RELATED ACTIVITIES, THE CNP ALSO ORGANISES SCIENTIFIC EVENTS ON A REGULAR BASIS. THESE EVENTS, WHICH INCLUDE COLLOQUIA SERIES AND CONFERENCES, BRING TO THE CCU DISTINGUISHED INTERNATIONAL NEUROSCIENTISTS. THE EVENTS ARE OPEN TO THE PUBLIC, THOUGH PRE-REGISTRATION AND SELECTION PROCESSES ARE OFTEN APPLIED.

Champalimaud Neuroscience Symposium
5th Edition

September 21-24, 2017.
Organisers: Megan Carey, Carlos Ribeiro.
Administrative coordination: CR Support Unit.

The 2016 symposium provided participants with an exciting and broad perspective on the state-of-the-art and the future of neuroscience research by bringing together world-renowned neuroscientists working on different fields of neuroscience.

The symposium was structured as a single-track programme where talks by invited speakers, as well as speakers selected from submitted abstracts, are interleaved with poster sessions where symposia participants present their research. In addition, to encourage interaction among all participants, alongside the scientific activities, social activities in different locations across Lisbon were organised as well.

List of speakers

Edvard Moser, Keynote speaker
Norwegian University of Science and Technology, Norway

David Anderson
California Institute of Technology, USA

Jose Carmena
University of California, Berkeley, USA

Pico Caroni
Friedrich Miescher Institute for Biomedical Research, Switzerland

Kathy Cullen
McGill University, Canada

Winfried Denk
Max Planck Institute of Neurobiology, Germany

Barry Dickson
Janelia Research Campus, USA

Valentina Emiliani
Centre National de la Recherche Scientifique, France

Hopi Hoekstra
Harvard University, USA

Tamas Horvath
Yale School of Medicine, USA

Sheena Josselyn
University of Toronto, Canada

Rob Malenka
Stanford School of Medicine, USA

Steven McCarroll
Harvard Medical School, USA

Thomas Mrsic-Flogel
University of Basel, Switzerland

Mala Murthy
Princeton University, USA

Michael Orger
Champalimaud Center for the Unknown, Portugal

Joe Paton
Champalimaud Center for the Unknown, Portugal

Carmen Sandi
Ecole Polytechnique Fédérale de Lausanne, Switzerland

Alex Schier
Harvard University, USA

Michal Schwartz
Weizmann Institute, Israel

Symposium 2016
The organisers of the symposium, Megan Carey and Carlos Ribeiro, during their opening lecture at the auditorium.

Agenda 2016

Jan

21
Colloquium Organization of neuronal population activity in sensory cortex.
Kenneth Harris, University College London, UK.

28
Colloquium Neural circuitry coordinating male copulation: The 'ins and outs' of Copulation.
Stephen Goodwi, University of Oxford, UK.

Feb

04
Colloquium A continuum of balanced states in cortical circuits. From single neuron dynamics to network state control.
Fred Wolf, Max Plank Institute for Dynamics and Self Organisation, Germany.

18
Colloquium NA
Björn Kampa, RWTH Aachen University, Germany

25
Colloquium Neural correlates of decision-making in health and disease.
Miguel Castelo-Branco, Institute for Biomedical Imaging and Life Sciences ((IBILI), University of Coimbra, Portugal.
School, USA.

10
Colloquium Synaptic plasticity mediated by AMPA receptor subunit GluA3.
Helmut Kessels, Netherlands Institute for Neuroscience, The Netherlands.

Mar

03
Colloquium Tasting from within? Exploration of the sensory interface linking the cerebrospinal fluid to dynamics of neuronal networks in vivo.
Claire Wyart, Pierre and Marie Curie University, France.

10
Colloquium Neural circuits coding locomotor speed in vertebrates.
Abdel El Manira, Department of Neuroscience, Karolinska Institute, Stockholm, Sweden.

17
Colloquium Novel approaches to high-speed 3D microscopy of in-vivo brain function and physiology.
Elizabeth Hillman, Columbia University, USA.

31
Colloquium The importance of coordination: rate and temporal coding in the hippocampus.
Thomas McHugh, RIKEN Brain Science Institute, Japan

Apr

20-22
Workshop
Brain-Body Interactions
Organisers: Cristina Ferreira, Antonia Groneberg, Madalena Fonseca. (All CR).

21
Colloquium Neural coding of space and time in entorhinal cortex.
Michael Hasselmo, Center for Systems Neuroscience, Boston University, USA.

May

06
Colloquium The Neural Basis of Timing and Temporal Processing.
Dean Buonomano, Brain Research Institute, UCLA, USA.

12
Colloquium Thalamo-cortical circuits underlying visual consciousness and decisions.
Melanie Wilke, University Medical Center Göttingen, Germany.

18-20
Advanced Course
Neuroscience of Emotions
Organisers: António Dias, Lorenza Calcatera, Jovin Jacobs, Marta Moita. (All CR)

19
Colloquium Encoding of action by Purkinje cells of the cerebellum.
Reza Shadmehr, Johns Hopkins University, USA.

26
Colloquium Wiring up a circuit to perform computations: development of direction selectivity.
Marla Feller, UC Berkeley, USA.

27-28
Conference
Neurodevelopmental Disorders: from neuroscience to the clinic - brain and life events
Organisers: Gabriela Martins (CR), Rui Costa (CR), Nuno Lobo Antunes (PIN clinic).

Jun

02
Colloquium Brain activity in sexual response and orgasm: fMRI studies.
Barry Komisaruk, Rutgers University, USA.

15
Colloquium Me and my Little Brain: autism and the cerebellum.
Peter Tsai, UT Southwestern Medical Center, USA.

23
Colloquium Sources and function of variation in vocal learning.
University of California, San Francisco, USA.

30
Colloquium Brown University, USA.
Christopher Moore, Brown University, USA.

Jul

10-31
Advanced Course
CAJAL Advanced Course: Behaviour Of Neural Systems
Organisers: Florian Engert (Harvard University, USA), Zachary Mainen (CR), Adam Kampff (University College London, UK).
Administrative coordination: Tânia Li Chen. (Pedro?)

21
Colloquium PI3K signaling during synaptic plasticity and disease.
José A. Esteban, CBMSO, Campus of the Universidad Autónoma de Madrid, Spain.

Aug

12/7-05/8
Advanced Course
CAJAL course in Computational Neuroscience
Organisers: Gilles Laurent (MPI Brain Research, Germany), Christian Machens (CR), Máté Lengyel (University of Cambridge, UK).
Administrative coordination: Tânia Li Chen. (Pedro?)

Sep

08
Colloquium Feed-forward and feedback circuits in the primate visual cortex.
Adam Kohn, Albert Einstein College of Medicine, USA.

15
Colloquium Circuit Mechanisms for Flexible Sensory Processing.
Vanessa Ruta, The Rockefeller University, USA.

16-19
5th Champalimaud Neuroscience Symposium
Organisers: Megan Carey, Carlos Ribeiro.
Administrative coordination: CR Administrative Unit.

18-20
Advanced Course
Advanced Course Hierarchical Processing
Organisers: Annelene Dahl, Gabriela Fioreze, Pietro Vertechi, Thabelo Khoboko, Alfonso Renart (All CR)

29
Colloquium Storing and updating models of the world for behavioural control.
Timothy Behrens, University of Oxford and University College London, UK.

Oct

06
Colloquium Control of Innate Social Behaviour: Nurture over Nature.
Nirao Shah, University of California, San Francisco, USA.

13
Colloquium Concept cells and their role in memory.
Rodrigo Quian Quiroga, University of Leicester, UK.

20
Colloquium The neurobiology of homeostasis. *Zachary Knight, University of California, San Francisco, USA.*

Nov

03
Colloquium Dynamics of population codes across cortex during navigation-based decision tasks.
Christopher Harvey, Harvard Medical School, USA.

10
Colloquium Synaptic plasticity mediated by AMPA receptor subunit GluA3.
Helmut Kessels, Netherlands Institute for Neuroscience, The Netherlands.

Dec

20
Ceremony INDP Graduation Ceremony 2016.
In this ceremony 26 Doctoral students received their diplomas..

Culture Highlights

AS ONE OF THE MEANS TO CREATE AN ENVIRONMENT WHERE INDIVIDUAL RESEARCHERS, IN ALL CAREER STAGES, ARE FAMILIAR WITH THE WORK OF EACH OTHER, SEVERAL ACTIVITIES HAPPEN REGULARLY AT THE CCU. TWO OF THESE ACTIVITIES ARE THE INTERNAL WEEKLY SEMINAR SERIES AND THE CR ANNUAL RETREAT.

CISS
Champalimaud Internal Seminar Series

Each week, two CNP researchers deliver a 25 minute presentation of their work, after which they receive feedback and questions from the CR community. These events, in addition to creating an atmosphere that facilitates collaboration, also provide a platform for junior researchers to advance their skills in preparing and delivering oral presentations to large audiences.

CR Annual Retreat
@Zambujeira do Mar

A central event shared by all CR researchers is the CR annual retreat. Each June, all CR members travel together to a remote location where they dedicate four days to getting reacquainted with each other's research and to simply having a good time together.

This year's retreat included CR-wide activities, such as talks by invited guests, covering topics on Experience-sampling methods (Jonathan Schooler), Science Education and Entrepreneurship (Greg Gage) and the balance between professional and personal life (Magdalena Bak-Maier) and included a pilot experiment on how to make collective decisions at CR (S3).

B

A

C

A - Chanpalimaud Internal Seminar Series
The CR community gathers at the Seminar Room for the weekly internal seminar where all researchers share their work.

B, C - Retreat activities
During the CR Annual Retreat, the tables of activities includes group discussions, games and poster sessions.

Support
Highlights

TWO MAIN BODIES FACILITATE THE SMOOTH FUNCTIONING OF THE CHAMPALIMAUD CENTRE FOR THE UNKNOWN, THE SCIENTIFIC AND TECHNOLOGICAL PLATFORMS AND THE CR SUPPORT UNITS.

Platforms
Scientific and Technological Platforms

Coordinator: Tânia Vinagre

The Scientific and Technological Platforms of the Champalimaud Centre for the Unknown carry out technical-scientific and specialised support work for the activities of research groups and clinicians. Platforms operate in a wide range of areas, from the development of sophisticated technologies in animal models, imaging tools, hardware and software, to resource management and research infrastructures.

Scientific & Technological Platforms:

- *Optical imaging & Microscopy*
- *Molecular Biology*
- *Scientific Software (SWP)*
- *Scientific Hardware Development (HWP)*
- *Fly Platform*
- *Fish Platform*
- *Vivarium*
- *Histopathology*
- *Glasswash & Media Preparation*

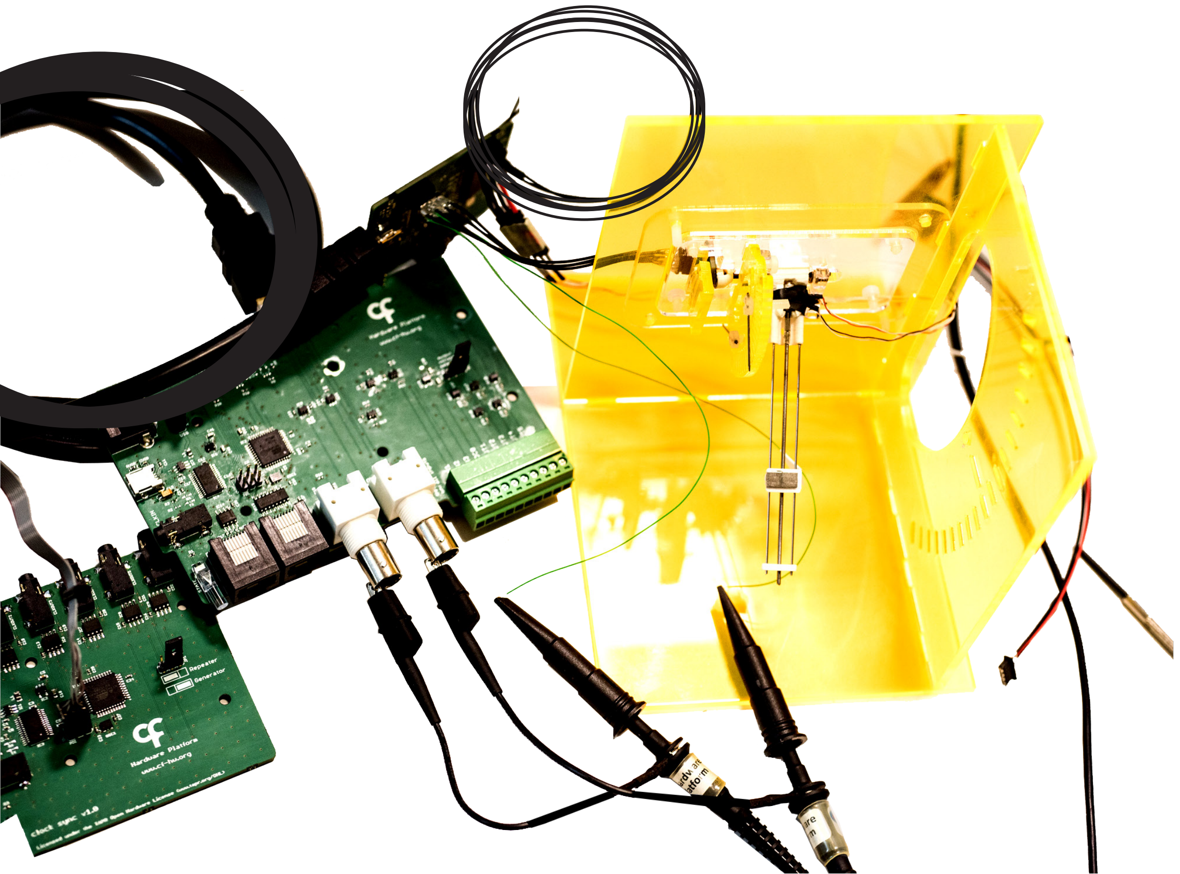
Highlights
Support for Neuroscience Research

In 2016, we highlight the participation of the platforms in Kickstarter projects, a collaborative development of community utility tools, namely in the optimisation of brain clearing protocols for three-dimensional microscopic visualisation, the application of genetic editing tools in the brains of adult animals or the development of shared software for computer vision applications. Also in 2016, the Fish Facility was featured in an international newsletter as a reference animal facility, and its coordinator became a member of the Executive Board of the Zebrafish Husbandry Association.

Development of clinical tools

At the international level, the platforms collaborated with the "Université Libre de Bruxelles" in the development of an endoscopic tool of clinical utility in the treatment of gastroesophageal reflux disease. Still in the clinical context, the platforms participated in the design and production of a fully autonomous remote patient monitoring system that allows for the home hospitalization of post-surgical patients.

A



A - Scientific Hardware Platform
Project *Archimedes*

The scientific hardware platform developed a tool called *Archimedes*. It's a lever that uses a special sensor to track the angular trajectory resulting from the force applied by an animal. Its ultra-small linear actuator slides a counter-weight beyond the fulcrum and changes the amount of force required to execute a press on a trial basis. This way, the mechanics of the experimental environment can be manipulated in real time.

CRSU
CR Support Units

Coordinator: Inês Soeiro

The CR Support Units (CRSU) provide all administrative, financial and operational assistance to the CR community. Accompanying the evolution and growth of Champalimaud Research, the support provided to CR's scientists also grows in organisation and capacities, blossoming with a new structure of seven specialised Units: Lab Administration, Human Resources, Events, Education & Courses, Operations, Sponsored Programmes and Science Communication. The CRSU team aims to provide all science administration, management and communication support to boost the work of scientists, maximising the focus on research.

Highlights
Restructuring and strengthening of CRSU

In 2016, CR's Administrative Unit was formally restructured as CR Support Units, with a more official organisation and strengthened expertise, such as a dedicated pre-award team, more support to CR's educational activities, and further capacities in science communication and operational management. This restructuring effort, in addition to enhancing administrative services, also streamlines the communication across Units and circles of CR organisation.

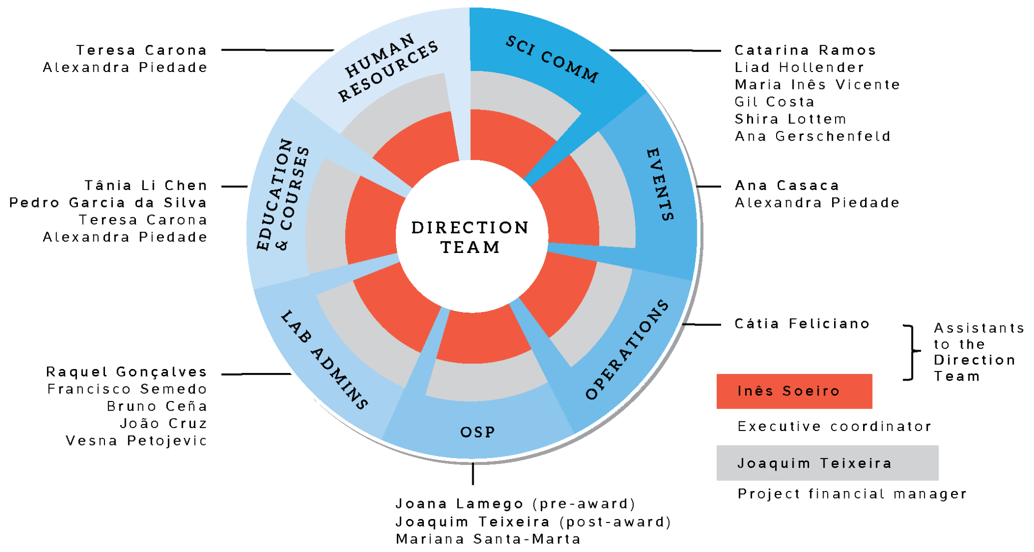
B - CR Support Units

This diagram presents the organisational structure of the CR Support Units, where the smooth flow of information across units is key.

C - The fly room

The fly room provides equipment and technical support to all scientists at CR who use the fruit fly as an animal model.

B



C

Outreach

ⓔ event ⓢ school visit
ⓘ interview ⓦ workshop

JAN

ⓔ **PORTUGAL 2036**
VENUE: PAVILHÃO DO CONHECIMENTO
TEAM: PEDRO FERREIRA E PATRÍCIA CORREIA

ⓢ **SCHOOL VISIT**
VENUE: CCU
TEAM: MARIA INÊS VICENTE & CATARINA RAMOS

FEB

ⓔ **ROUND TABLE DISCUSSION ABOUT COGNITIVE ENHANCEMENT**
VENUE: PAVILHÃO DO CONHECIMENTO
TEAM: ALBINO OLIVEIRA-MAIA

ⓔ **AR | RESPIRE CONNOSCO EVENT: "THE INVISIBLE LINK – DIALOGUES BETWEEN LAB AND CLINIC IN NEURODEGENERATIVE DISORDERS"**
VENUE: CCU
TEAM: LIAD HOLLENDER, DANIEL NUNES, JOAQUIM ALVES DA SILVA, DURVAL COSTA, MARATONA DA SAÚDE

ⓦ **WORKSHOP & SPEED DATING – NÚCLEO DE BIOLOGIA CELULAR E MOLECULAR**
VENUE: FACULDADE DE CIÊNCIAS E TECNOLOGIA DA UNIVERSIDADE NOVA DE LISBOA
TEAM: MARIA INÊS VICENTE, CATARINA RAMOS

ⓘ **COLLABORATION WITH MARATONA DA SAÚDE**
VENUE: AGORA NÓS – RTP 1 TV CHANNEL
TEAM: TIAGO MARQUES, JOAQUIM ALVES DA SILVA, DANIEL NUNES

ⓢ **SCHOOL VISIT**
VENUE: CCU
TEAM: MARIA INÊS VICENTE & CATARINA RAMOS

ⓢ **SCHOOL VISIT**
VENUE: CCU
TEAM: MARIA INÊS VICENTE, CATARINA RAMOS

MAR

ⓢ **SCHOOL VISIT**
VENUE: CCU
TEAM: MARIA INÊS VICENTE, CATARINA RAMOS

ⓘ **COLLABORATION WITH MARATONA DA SAÚDE**
VENUE: PROVA ORAL – RÁDIO ANT3NA
TEAM: MARCELO MENDONÇA

ⓢ **HANDS-ON ACTIVITY**
VENUE: ESCOLA DA TORRE, LISBOA
TEAM: INÊS SOEIRO, LIAD HOLLENDER

ⓢ **VISIT FROM ESCOLA CIÊNCIA VIVA**
VENUE: CCU
TEAM: MARIA INÊS VICENTE, CATARINA RAMOS

ⓢ **BRAIN AWARENESS WEEK**
VENUE: ESCOLA VIRGÍLIO FERREIRA, TELHEIRAS
TEAM: MARIA INÊS VICENTE, CATARINA RAMOS

ⓔ **AR | RESPIRE CONNOSCO EVENT: "REBUILDING FROM CONFLICT – THE POWER OF EDUCATION IN EMERGENCIES"**
VENUE: CCU
TEAM: ANNA HOBBISS, ANDRÉ VALENTE, ANA NUNES, MARTA MOITA, PLATAFORMA GLOBAL DE ASSISTÊNCIA ACADÉMICA DE EMERGÊNCIA A ESTUDANTES SÍRIOS

APR

ⓔ **PERFORMANCE DANCE AND NEUROSCIENCE "ENSAIO"**
VENUE: TEATRO JOSÉ LÚCIO DA SILVA, LEIRIA
TEAM: ANTONIA GRONEBERG, ANGELO CID

ⓔ **AR | RESPIRE CONNOSCO EVENT: "GUT THINKING – HOW YOUR MICROBES INFLUENCE YOUR LIFE"**
VENUE: CCU
TEAM: MARTA CAMACHO, SIMONE LACKNER, GIL COSTA, INVESTIGADORES DO INSTITUTO DE TECNOLOGIA QUÍMICA E BIOLÓGICA ANTÓNIO XAVIER

MAY

ⓘ **VIDEO "DESIGN THE FUTURE"**
VENUE: WEBSITE DA FUNDAÇÃO VODAFONE
TEAM: TIAGO MARQUES

ⓔ **ROUND TABLE "CONVERSAS C: ÉTICA NA COMUNICAÇÃO DE CIÊNCIA"**
VENUE: PAVILHÃO DO CONHECIMENTO
TEAM: CATARINA RAMOS

ⓔ **ORAL AND POSTER PRESENTATION AT THE ANNUAL PORTUGUESE SCICOM CONFERENCE**
VENUE: PAVILHÃO DO CONHECIMENTO
TEAM: MARIA INÊS VICENTE, CLARA FERREIRA

ⓔ **SEMINAR CYCLE "CIÊNCIA, EDUCAÇÃO E DEMOCRACIA"**
VENUE: CENTRO DE FORMAÇÃO DE ESCOLAS ANTÓNIO SÉRGIO, ESCOLA SECUNDÁRIA D. DINIS, LISBOA
TEAM: TIAGO MARQUES

JUN

ⓘ **VIDEO COHITEC**
VENUE: COHITEC WEBSITE
TEAM: FERNANDO SANTOS, RUI COSTA

ⓘ **VIDEO "DESIGN THE FUTURE"**
VENUE: FUNDAÇÃO VODAFONE WEBSITE
TEAM: GIL COSTA, JOANA RIGATO

ⓔ **AR | RESPIRE CONNOSCO EVENT: "OUT OF FOCUS – WHEN THE BRAIN WONDERS TOO MUCH"**
VENUE: CCU
TEAM: TIAGO MARQUES, ERIC DEWITT, TIAGO QUENDERA, BERNARDO BARAHONA-CORRÊA

ⓘ **RADIO SHOW HORA DO BOLO**
VENUE: RADAR, RÁDIO
TEAM: TIAGO MARQUES

ⓦ **WORKSHOP SOMATIC RHYTHM**
VENUE: CCU AMPHITHEATRE
EQUIPA: TIAGO QUENDERA, GAUTAM AGARWAL

JUL

ⓦ **WORKSHOP "MOSCAS DA FRUTA HIGH-TECH: COMO É QUE AS MOSCAS DA FRUTA NOS AJUDAM A ENTENDER O CÉREBRO?"**
VENUE: CCU TEACHING LAB
TEAM: MARIA INÊS VICENTE, CATARINA RAMOS

SET

ⓔ **EUROPEAN INVESTIGATORS NIGHT**
VENUE: PAVILHÃO DO CONHECIMENTO AND CENTRO CIÊNCIA VIVA DE LAGOS
TEAM: TIAGO MONTEIRO, FILIPE RODRIGUES, MARIA INÊS VICENTE, MARTA CAMACHO, MUSIC BAND "ARCH"

NOV

ⓦ **SCIENCE AND TECHNOLOGY WEEK - WORKSHOP "QUANTOS TEMPOS TEM O CÉREBRO?"**
VENUE: CCU TEACHING LAB
TEAM: MARIA INÊS VICENTE, CATARINA RAMOS

16 Total outreach activities outside CCU

12 Total outreach activities inside CCU

Science Communication Unit
Highlights

ONE OF CR'S STATED GOALS IS TO SHARE ITS KNOWLEDGE NOT ONLY WITHIN THE SCIENTIFIC COMMUNITY, BUT ALSO WITH THE COMMUNITY AT LARGE. MANY CR RESEARCHERS, AT ALL CAREER STAGES, ADOPT THIS VISION AND CHOOSE TO ORGANISE AND PARTICIPATE IN VARIOUS OUTREACH ACTIVITIES, BOTH AT AND OUTSIDE OF THE CCU.

A - Ar Magazine: *"Neurons that control judgment of time discovered in the mouse brain"*
An article by *Ana Greschenfeld* in AR Magazine. illustration by *Gil Costa*.

B - Ar Events: *"Gut Thinking"*
An interactive installation made in collaboration with ITQB.

Science Communication Office

Coordinator: Catarina Ramos

A leading scientific institution should not only produce the best quality research but also work with different society sectors to share with them the wonders of science, for the benefit of future citizens. To produce a long-lasting impact, science must reach society and engage it in its discoveries and breakthroughs. One of the core missions of Champalimaud Research (CR) is to demystify science so the public can understand the importance of what we do and is invited to engage with us in the amazement of scientific discovery.

The CR Science Communication Unit has been actively involved in multiple initiatives that start at the Champalimaud Centre for the Unknown but go beyond its walls and reach a diversity of audiences.

This Unit is responsible for disseminating information on the activities and ongoing or emerging objectives of CR to all relevant parties, for maintaining fluent internal and external communication channels, including CR's online presence, liaising with the media, the production of communication documents/materials, such as the annual report. This Unit also coordinates science communication initiatives that range from science education and outreach events to the organization of scientific meetings. The team also supports the CR community in their scientific endeavors, with in-house scientific design and illustration.

Outreach
Ar | Respire connosco

Ar is an outreach initiative created by a group of students and researchers from the Champalimaud Research which started in 2011. Since then, more than 30 events have been produced. The events range from talks, dance performances, debates and interactive projects, all connected (directly or peripherally) with science and scientific ideas. Alongside, Ar has an online magazine, with information about upcoming and past events and articles about interesting scientific development.

Ar Events

The Invisible Link , Feb 10
Dialogues between lab and clinic in neurodegenerative disorders

Rebuilding from Conflict, Mar 11
The Power of Education in Emergencies

Gut Thinking, Apr 21
How your Microbes Influence your Life

Out of Focus, Jun 30
When the Brain Wanders Too Much

Ar Magazine

In early 2016, the online presence of Ar | Respire connosco was redesigned and a new website and online magazine were launched. This new magazine aims to be a platform for researchers from our centre and worldwide to express themselves. The articles, from interviews with researchers, recent discoveries, to the interplay of science and society cover a wide range of scientific topics. A group of editors from our institute, both researchers and from the Science Communication Office, curate the magazine. In 2016, 23 articles were published in Ar Magazine.

A

B

Education
Summer Workshop

Jun 27 - Jul 1

"Fruit flies go high-tech: how can fruit flies help us understand the brain?"

This workshop, created under the Ocupação Científica dos Jovens nas Férias program of Ciência Viva - National Agency for Scientific and Technological Literacy, consisted of a journey through two laboratories of Champalimaud Research, where students were challenged to think, discuss, find strategies to address real issues and problems that researchers encounter on a daily basis during their research project, such as designing experiments, analyzing data, making experimental predictions.

Press Office
CR Presence in the Media

This office manages requests from the media and issues press releases regularly. In 2016, 16 press releases were produced, resulting in around 150 references in national media and 110 in international media (these numbers are underestimations). In addition the team mediated 15 requests from national media.

Kickstarter Project
CR Science Careers

Organizers: Clara Ferreira, João Afonso, Silvana Araújo, Maria Inês Vicente, Catarina Ramos

The objective of this project is to raise awareness amongst PhD students and postdocs about the breadth of science careers, both academic and non-academic, and develop required skills for these careers. We aim to do this by providing more in-depth knowledge on/training for these careers. More specifically, we started a series of workshops and networking sessions, where we invite representatives from both academic and non-academic fields. In parallel, in order we to facilitate the exchange of experiences between current CR members and CR-alumni we created a LinkedIn CR-alumni network.

Skill Analysis & Career Options
Guest: Sarah Blackford

Writing an effective curriculum vitae
Guest: Sarah Blackford

Graphic Design for Scientists
Guest: Gil Costa

Workshop
Science and Technology Week

Nov 26

"How many "times" does the brain has?"

During the Science and Technology Week, this workshop brought together a group of children and families to the Teaching Lab of the Champalimaud Centre for the Unknown. How does the brain know how much time has passed? Does the brain has a time-counting machine, second-by-second, just like a watch? Or does time in the brain stretch and shrink? Is time in the brain like a wave? These were the questions that served as the starting point for this workshop. The Teaching Lab was converted into a space of time exploration and a set of dynamic activities allowed us to work on the research being conducted at the Learning Lab.

C - Ciência Viva - school visit
Elementary school students from Escola Ciência Viva during their visit to the CCU.

D - How many "times" does the brain has?
Children and families during the workshop "Quantos tempos o Cérebro tem?" that was held in the Teaching Lab.

E, F - Ocupação Cientifica dos Jovens nas Férias – Ciência Viva.
High school students during the internship programme "Ocupação Cientifica dos Jovens nas Férias", that took place in the teaching lab.

C

D

E

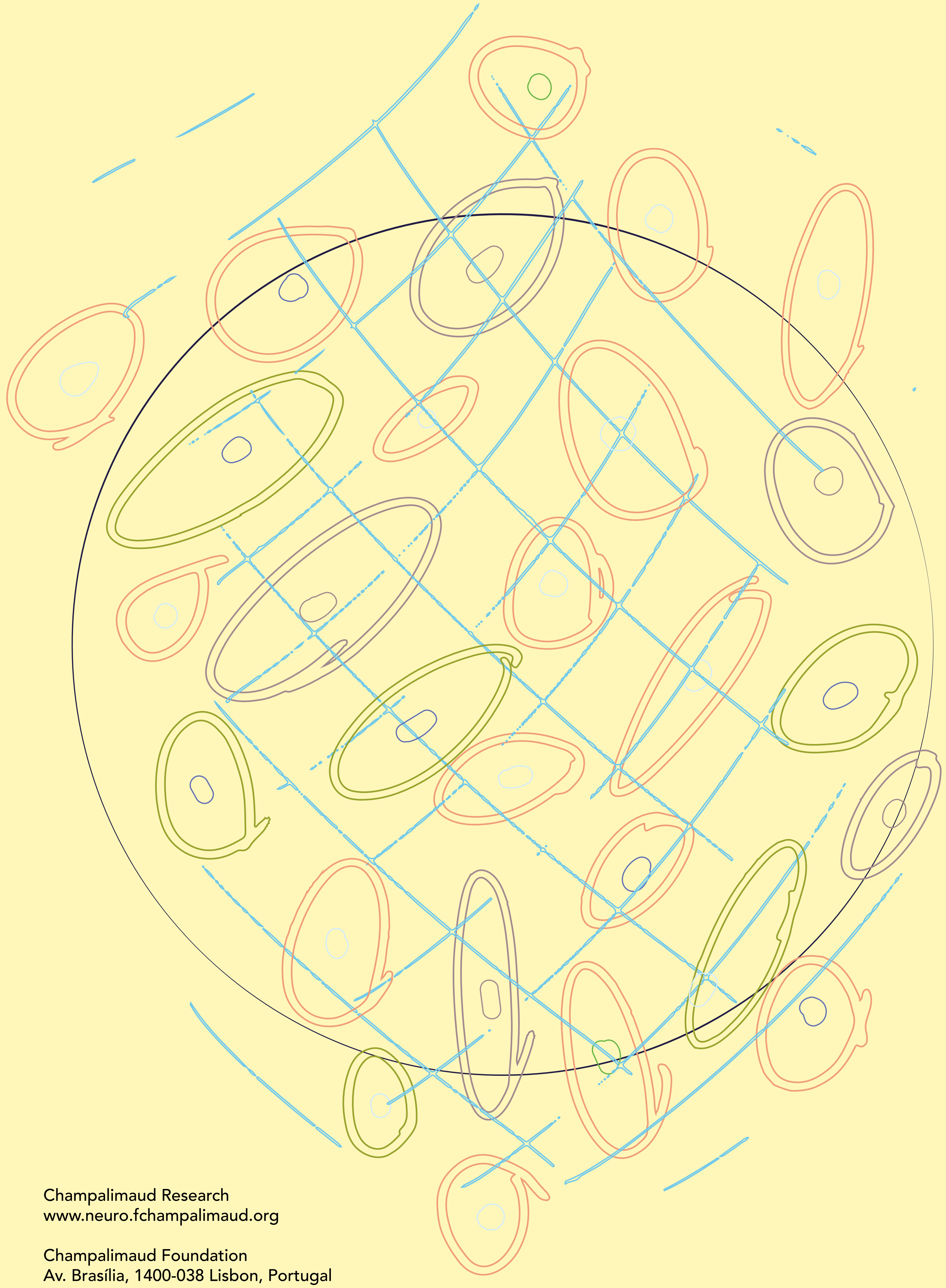
F

A View Of The Interior Tropical Garden Seen From The Second Floor Open Lab.
Photo: Hanne Stensola

Champalimaud Research
www.neuro.fchampalimaud.org

Champalimaud Foundation
Av. Brasília, 1400-038 Lisbon, Portugal
www.fchampalimaud.org

Champalimaud Foundation



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