The "Cellular physiology of cortical microcircuits" team at ICM is recruiting a Master student with a possible extension to PhD position

CANNABINOID RECEPTORS IN CORTICAL VISUAL ENCODING
6 month internship - Starting January 2019
Paris 13ème

The Institut du Cerveau et de la Moelle épinière is a private foundation which objective is fundamental and clinical research of the nervous system. United in one site, 600 researchers, engineers and clinicians cover most of the disciplines in Neurology with the aim to accelerate discoveries in brain functioning, and developments of treatment of diseases such as Alzheimer, Parkinson, multiple sclerosis, epilepsy, depression, paraplegia, tetraplegia, etc.

DESCRIPTION OF THE TEAM

Our aim: The cerebral cortex (neocortex) is the site where all sensory information is integrated to generate complex behaviors and sophisticated cognitive functions, such as learning, memory, sensory perception and attention. This is accomplished through the concerted, synchronous, and often rhythmic activity of intertwined cortical networks formed by highly heterogeneous neuronal populations, which connect to each other following a detailed blueprint. Therefore, cortical network activity results from very specific patterns of synaptic connections between heterogeneous neuron types. In particular, inhibitory interneurons are highly diverse and functionally organized in a precise division of labor within cortical circuits. Importantly, synaptic inhibition sculpts all forms of cortical activity. Overall, the lab studies how synaptic inhibition and its plasticity control the flow of information within and across cortical networks (see Figure 1). Studying how specific synaptic pathways generate, control and modulate network activities and control the output of large populations of cortical principal neurons is key to understand the synaptic and circuit correlates of cognition. This has important implications for several neurological and psychiatric diseases. Indeed, accumulating evidence indicates that the malfunctioning of specific cortical circuits lead to devastating brain disease, such as epilepsy, schizophrenia and autism.

Techniques: The team uses a combination of approaches, including cellular and molecular biology, neuroanatomy, electrophysiology in brain slices and in vivo, computational approaches, 2-photon imaging and photo-stimulation, optogenetics, genetic manipulation of specific cortical neuron types.
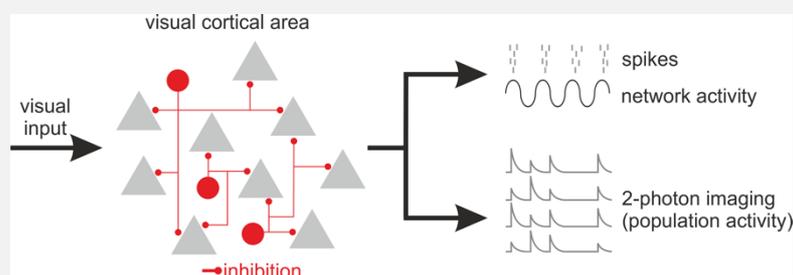

Figure 1: The lab studies how sensory (e.g. visual) input is decoded by a cortical network formed by excitatory principal neurons (gray triangles) strongly modulated by inhibitory interneurons (red circles). We use electrophysiological and 2-photon imaging approaches to infer activity of single neurons embedded in complex networks.

We are: The lab includes a diverse ecosystem of expertise, including electrophysiologists, cell biologists and biophysicists.

You are! The lab is looking for a motivated student possessing the computational skills that will help us *i)* analyzing the activity from several neurons to infer prominent functional network dynamics, and *ii)* building complex network models based on our experimental data.

Keywords:

THE PROJECT: CANNABINOID RECEPTORS IN CORTICAL VISUAL ENCODING

The eye captures images on its retina. But what we "*see*" is a result of how the brain receives and rebuilds the signals from the retina. In the 1960s to 70s, pioneers Hubel and Wiesel (in the 1960s) revealed the pattern of organization of brain cells that process vision. More interestingly, they also discovered how connections between nerve cells filter and transform sensory information on its way from the retina to the cerebral cortex. Sensory systems, including the visual system, are highly organized and hierarchal. Visual information collected by the retina is relayed (via the thalamus) to the primary visual neocortical area V1, mainly in layer 4. Sensory information is then passed along to other cortical layers in a stereotyped sequence before being sent to associative visual areas, such as V2. In particular, inhibition from a specific subtype of interneurons (parvalbumin interneurons) is believed to be important in rhythm generation and visual information processing. Importantly, however, the properties and roles of another prominent interneuron subtype (expressing cholecystokinin, or CCK) within neocortical circuits is completely unknown. Interestingly, these interneurons express the cannabinoid receptor type 1 (CB1), which is responsible for strong plasticity of their GABAergic synapses. Indeed, endogenous marijuana-like compounds strongly reduces the inhibitory grip of these interneurons during the transfer of information within cortical networks (see Figure 2).
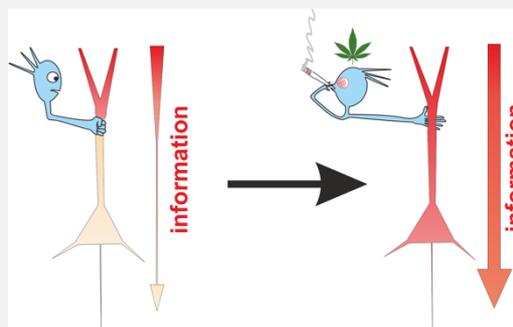

Figure 2: Schematic of endocannabinoid modulation of information transfer between cortical neurons.

We have observed a differential connectivity logic of these interneurons in V1 and V2. Therefore, it will be important to pinpoint the exact role of this cell type and of CB1R-mediated plasticity in these two visual areas during visual encoding. Specifically, we hypothesize that CB1R-dependent differential control of synaptic plasticity in different layers of different visual areas plays a crucial role in the integration of the sensory stimulus. This hypothesis will be tested by studying network γ-oscillations and 2-photon Ca^{2+} imaging of large neuronal populations (Figure 1). Oscillations in the γ-frequency band synchronize distributed cell assemblies, and facilitate information transfer within and across brain areas. Interestingly, γ-rhythms are associated with perceptual and cognitive functions that are compromised in several neurodevelopmental diseases. The excellent spatial resolution typical of 2-photon imaging allows revealing the simultaneous activity of large neuronal populations. This project will thus reveal the contribution of CCK/CB1 interneurons during visual encoding and their association to cognitive-relevant network oscillations.

THE TEAM

Group Leader:
Alberto Bacci, DR CNRS

Staff Researchers:
Joana Lourenço, CR INSERM
Laurence Cathala, MCU Sorbonne Université

Technical staff:
Andrea Aguirre, IE ICM

Postdoctoral fellows:
Angela De Stasi
Javier Zorilla de San Martin
To be hired

Graduate students:
Cristina Donato
Lucie Gallet
To be hired

ORGANIZATION OF THE INTERNSHIP

The student will be in contact with the experimental settings, but he/she will be mostly involved in data analysis and modeling. He/she will be constantly monitored by one or two experienced researchers. He/she will be exposed to a variety of scientific approaches, including cell biology, electrophysiology, biophysics and 2-photon imaging. He/she will attend all lab meetings and will be required to present at least once. Ability of speaking and writing in English is strongly appreciated.

SKILLS TO DEVELOP AND/OR LEARN DURING THE INTERNSHIP

The student will learn to manage a research project in collaboration with other team members. He/she will learn the fundamentals of neurophysiology at the single-neuron and network levels. He/she will contribute with analytical skills.

YOUR PROFILE

We are looking for an enthusiastic young student willing to be involved in a research project on cortical circuit modulation by interneurons. The ideal candidate should have strong theoretical background for applying signal-processing methods. He/she will be required to program in Matlab or Python. The candidate should have some knowledge of basic computational neuroscience and being interested in neuronal networks. Good knowledge of English language is a plus.

Please send a motivation letter and CV to:
alberto.bacci@icm-institute.org and joana.lourenco@icm-institute.org