

Lab's description

Living systems are never at rest. They are highly dynamic in order to perceive the ever-changing world. In the Barral lab, we are generally interested in the interface between biophysics and neurosciences and more specifically in the biological strategies that organs and organisms have developed to actively sense their environment. These strategies are best illustrated in the sense of hearing. We study this issue from a physical perspective at the level of the peripheral auditory system and at the level of the central nervous system.

Project summary

Processing of auditory information in the brain is complex because information not only flows from the auditory periphery to the central nervous system but also from the brain to the ear (see Marin et al, *Mol Cell Neurosci.* 2022). As a result, efferent neuronal signals can modulate the mechanical properties of the cochlea. Ideally, we would like to know the cochlear output precisely to study its effect on neural representations. However, because cochlear mechanics and neuronal processing are reciprocally coupled through mechano-electrical feedback, it requires specific tools to uncouple them and to decode the transformation of complex acoustic stimuli by the brain.

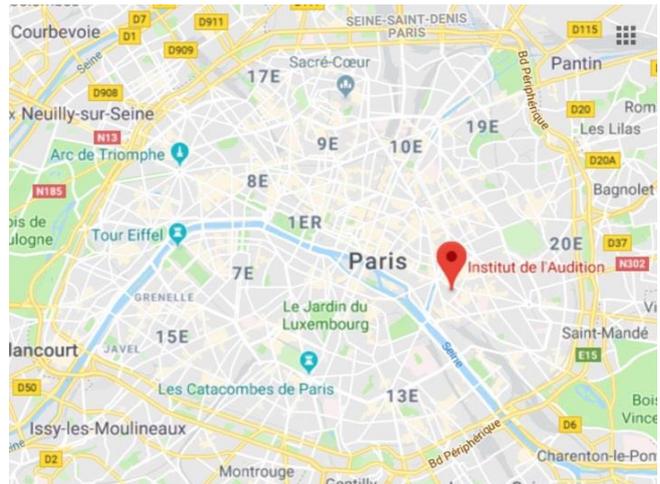
The aim of the research team is to study how information about sound frequency is propagated from the auditory periphery to the cortex. To understand how sound features are encoded in the brain we would need to vary specific parameters of the input and measure how it affects neuronal firing. Recent progress in optogenetics have allowed to activate neuronal circuits precisely. In the lab, we use these tools to control the cochlear output and activate optogenetically cochlear hair cells *in vivo*. Optical methods allow to focalize the beam of a laser onto several cellular targets and rapidly update the temporal pattern of stimulation. Based on recent developments (see Kim et al, *PNAS* 2022), the student will develop an experimental protocol to transparentize the cochlear bone in order to visualize auditory hair cells *in vivo* using 2-photon imaging and without the need of opening the cochlear structure. Once this step will be leveled up, the student will be able to use the custom microscope setup that we developed in the lab. The 2-photon microscope has a stimulation light path based on holographic light patterning to activate simultaneously (but independently) single hair cells with millisecond precision. Concurrently, we will perform recordings from large populations of neurons at different stages of the auditory pathway using multi-electrode arrays. The final goal is to study what type of neuronal circuit can propagate information from the auditory periphery to the brain and to test the hypothesis of an underlying feedforward network (see Barral et al, *Nature Communications* 2019).

The student will learn techniques from optics, microscopy, holography, electrophysiology, and data analysis.

Contact: jeremie.barral@pasteur.fr

Website: <http://www.barral-lab.org>
<https://www.institut-audition.fr>

Institution: Institut de l'Audition
63 rue de Charenton
75012 Paris
France



References

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