

## Holographic light stimulation of the cochlea to study auditory processing

### Host lab

*Name:* Institut de l'Audition, Institut Pasteur

*Address:* Institut de l'Audition, 63 rue de Charenton, 75012 Paris

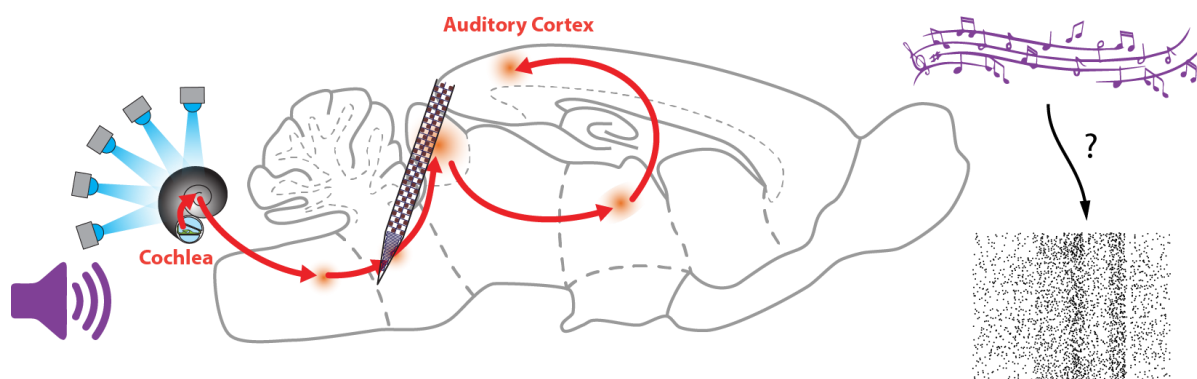
*Team:* Neural coding in the auditory pathway

*Web page:* <https://www.barral-lab.org/>

*Supervisor:* Jérémie Barral (jeremie.barral@pasteur.fr)

### Summary of lab's interests

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 studied 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. 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 will require specific tools to uncouple them and to decode the transformation of complex acoustic stimuli by the brain.

The aim of this project 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. Here we will use these tools to control the cochlear output and realize the first optogenetic activation of 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. The student will design a setup based on holographic light patterning to be able to stimulate simultaneously (but independently) single hair cells with millisecond precision.

### Interdisciplinary aspect of the project

This project combines the design of a precise optical setup and recording of large populations of neurons to understand the neuronal circuit that enables the transformation of sounds by the auditory system. Ultimately, it will permit to build new models of the auditory system. Taken together, the project requires approaches from optics, microscopy, electrophysiology, computation, and analysis of large datasets.

### References

#### *General publications about the research subject*

- Theunissen, F.E. and J.E. Elie, Neural processing of natural sounds. **Nat Rev Neurosci**, 2014. 15(6): p. 355-66.
- Fettiplace, R. and C.M. Hackney, The sensory and motor roles of auditory hair cells. **Nat Rev Neurosci**, 2006. 7(1): p. 19-29.
- Yizhar, O., et al., Optogenetics in neural systems. **Neuron**, 2011. 71(1): p. 9-34.
- Ronzitti, E., et al., Recent advances in patterned photostimulation for optogenetics. **Journal of Optics**, 2017. 19(11).

#### *Selected publications from the supervisor:*

- Barral J, Wang XJ, and Reyes AD (2019). Propagation of temporal and rate signals in cultured multilayer networks. **Nature Communications** 10(1):3969
- Barral J, Jülicher F, and Martin P (2018). Friction from transduction channels' gating affects spontaneous hair-bundle oscillations. **Biophysical Journal** 114(2) : 425-436
- Barral J and Reyes AD (2017) Optogenetic stimulation and recording of primary cultured neurons with spatiotemporal control. **Bio-Protocol** 7(12): e2335
- Barral J and Reyes AD (2016). Synaptic scaling rule preserves excitatory/inhibitory balance and salient neuronal network dynamics. **Nature Neuroscience** 19 :1690-1696
- Barral J and Martin P (2012). Phantom tones and suppressive masking by active nonlinear oscillation of the hair-cell bundle. **P.N.A.S.** 109 : E1344-51
- Barral J, Dierkes K, Lindner B, Jülicher J, and Martin P (2010). Coupling a sensory hair-cell bundle to cyber clones enhances nonlinear amplification. **P.N.A.S.** 107 : 8079-8084