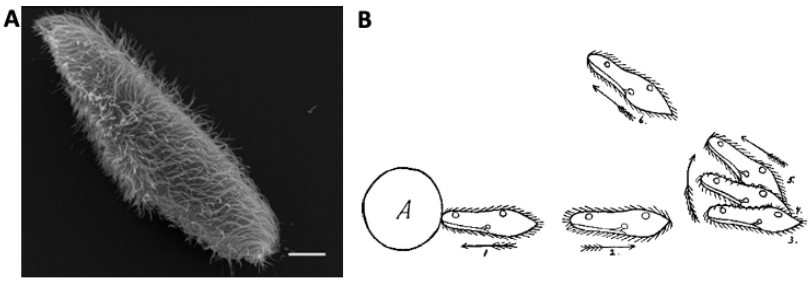
Conditioning *Paramecium* with sound

Contact: romain.brette@inserm.fr

Paramecium is a unicellular organism that swims in fresh water by beating thousands of cilia. When it is stimulated (mechanically, chemically, optically, thermally…), it often swims backward then turns and swims forward again. This "avoiding reaction" is triggered by a calcium-based action potential. For this reason, some authors have called *Paramecium* a "swimming neuron" (Brette, 2021). This project belongs to a broader project aiming at developing integrative models of *Paramecium*, bridging physiology and behavior. This is a collaborative effort between the labs of Romain Brette (neuroscience, Vision Institute), Alexis Prevost et Laetitia Pontani (physics, Laboratoire Jean Perrin) and Eric Meyer (genetics, Ecole Normale Supérieure), in Paris. The team has already developed experimental techniques (behavior and electrophysiology), including a device to immobilize *Paramecium* for electrophysiology experiments (Kulkarni et al., 2020), and a basic biophysical model of the action potential and electromotor coupling.



A, Scanning electron microscopy image of Paramecium tetraurelia (scale bar: 10 µm) (Valentine et al., 2012). B, Avoiding reaction against an obstacle, as illustrated by Jennings (Jennings, 1906).

This project aims at reproducing a conditioning experiment in *Paramecium*, and better understanding its basis. Hennessey et al. (1979) managed to train *Paramecium* to react to sounds. When a tone is played by a speaker below the slide, *Paramecium* shows no reaction. However, when the tone is paired with electrical stimulation triggered in the middle of the tone, *Paramecium* reacts to the stimulus with an avoiding reaction, then after a few trials gives an avoiding reaction at the onset of the tone, in anticipation of the electrical stimulus.

First, the student will reproduce this experiment. Second, the student will examine the temporal constraints between the conditioned stimulus and the unconditioned stimulus. Finally, the experiment will be reproduced electrophysiologically in an immobilized cell by mechanical stimulation.

The project can be adapted to the duration of the project and the profile of the student.

Brette R (2021) Integrative Neuroscience of Paramecium, a "Swimming Neuron." eNeuro 8:ENEURO.0018-21.2021.

Jennings HS (1906) Behavior of the lower organisms. New York, The Columbia university press, The Macmillan company, agents; [etc., etc.].

Kulkarni A, Elices I, Escoubet N, Pontani L-L, Prevost AM, Brette R (2020) A simple device to immobilize protists for electrophysiology and microinjection. Journal of Experimental Biology 223.

Valentine MS, Rajendran A, Yano J, Weeraratne SD, Beisson J, Cohen J, Koll F, Van Houten J (2012) ParameciumBBS genes are key to presence of channels in Cilia. Cilia 1:16.