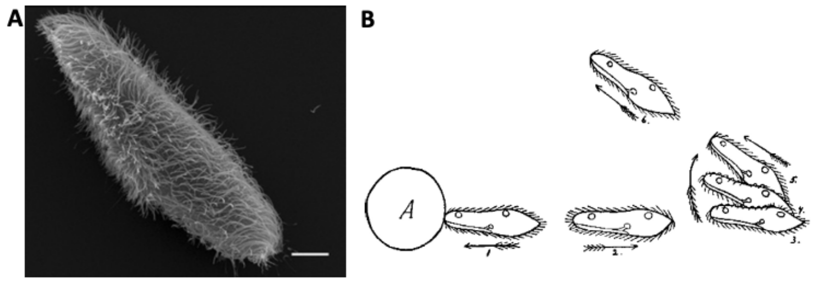
Behavioral tracking of *Paramecium* with deep learning

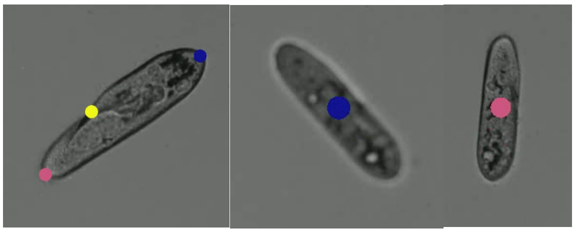
Contact: romain.brette@inserm.fr

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 goal of this project is to develop deep learning tools to localize *Paramecium* in microscopy videos as well as detailed features. To this end, the student will use DeepLabCut (Mathis et al., 2018), or any other relevant tool. For example, it is possible to locate the oral groove, or to distinguish whether the cell is above or below the focal plane.



This will be used to perform live tracking of paramecia with a motorized stage and microscope (Sehara et al., 2021), in the presence of obstacles.

To go further, the student will train networks to predict dynamical features of trajectories. For example, by training a network to predict the cell’s position in the next frame, the network will be able to distinguish between anterior and posterior ends. Another example: *Paramecium* tends to swim in helicoidal paths, with the oral groove facing the spiral axis:

By training a network to predict the cell’s angle relative to the spiral, the network will be able to estimate the position of the oral groove.

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

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