Paramecium chemotaxis

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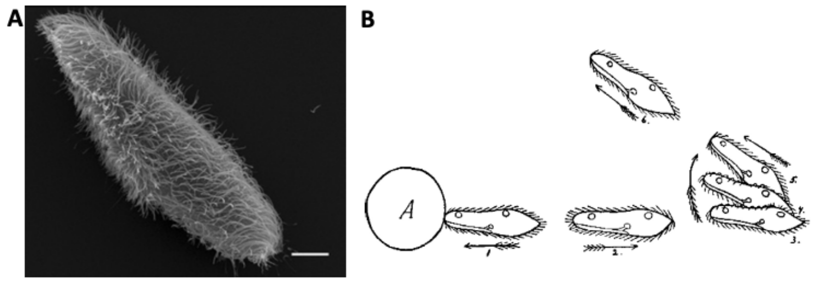
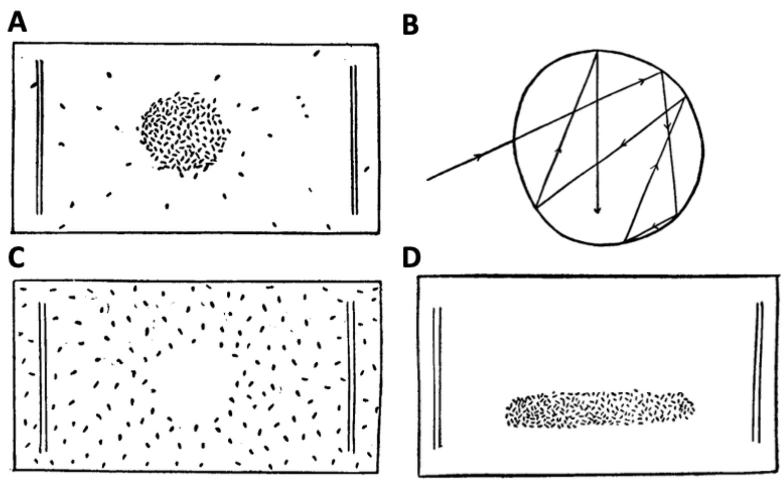
Paramecium is a unicellular organism that swims in fresh water by beating thousands of cilia. When it is stimulated (mechanically, chemically, optically, thermally…), it often swims backward then turns and swims forward again. This "avoiding reaction" is triggered by a calcium-based action potential. 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 better understanding chemotaxis and more generally chemosensitivity in *Paramecium*. *Paramecium* is sensitive to a variety of chemical compounds (Dryl, 1973; H. S. Jennings, 1899; NAKATANI, 1968; Valentine et al., 2008). In the 19th century, Jennings described the behavior of paramecia gathering in a drop of weak acid. He linked this behavior to the avoiding reaction. When *Paramecium* enters a drop of acid, its course is unchanged; but when it reaches the border of the drop, it gives the avoiding reaction and therefore remains in the drop. On the contrary, alkaline solutions are repellent: an avoiding reaction is triggered as soon as the alkaline solution is reached. More recently, various substances have been characterized as attractant or repellent based on the accumulation of paramecia in a test solution relative to a control solution, using different behavioral assays (Leick and Helle, 1983; Levandowsky et al., 1984; Nakazato and Naitoh, 1993; Valentine and Van Houten, 2016; Van Houten et al., 1975).



A, Gathering of paramecia in a drop of weakly acid solution (Herbert S. Jennings, 1899). B, Path followed by Paramecium in a drop of acid (Jennings, 1906). C, Paramecia avoiding a drop of sodium carbonate (Herbert S.

Jennings, 1899). D, Paramecia gathering in a cloud of carbon dioxide generated by their respiration (Herbert S. Jennings, 1899).

First, the student will measure and analyze detailed trajectories of paramecia with drops of attracting or repelling substances, in particular what happens exactly at the interface. Trajectories will then be measured in a concentration gradient, in a flat capillary. These trajectories will be used to estimate models of chemotaxis, and to relate them with existing models of bacterial chemotaxis. Finally, depending on time and interest, chemical transduction will be studied in the electrophysiology setup, by measuring currents triggered by the application of substances.

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

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