Integrative modeling of a mechanosensitive organism, *Paramecium*

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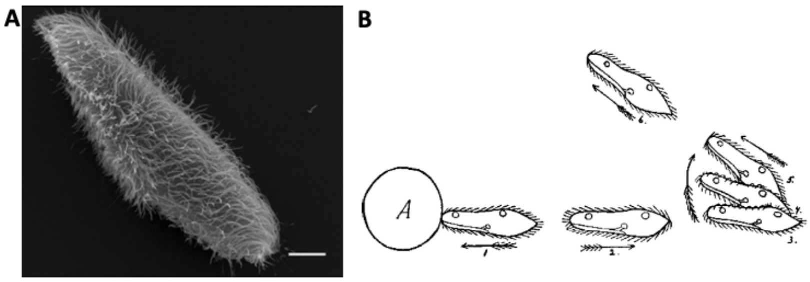
More details: http://romainbrette.fr/neuroscience-of-a-swimming-neuron/

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 laboratories of Romain Brette (neuroscience, Vision Institute), Alexis Prevost and Léa-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 developing an integrated model of mechanosensitivity in *Paramecium*. Touching the anterior end of *Paramecium* increases the membrane potential (depolarizes) by opening ionic channels, most likely of the Piezo family. This may trigger an action potential, leading to an avoiding reaction: the organism swims backward and thus escapes the stimulus. Touching the posterior end decreases the membrane potential (hyperpolarizes) by opening another type of ionic channel. This triggers an increase in ciliary beating, and thus *Paramecium* escapes the stimulus by accelerating forward swimming.

A first model of mechanotransduction will be established based on the existing literature (Machemer, 1985). This will be completed by electrophysiological experiments, where a glass probe stimulates the membrane while the electrical response of the membrane is recorded. In a second phase, the transduction model will be integrated with a model of the action potential and electromotor coupling, to predict the movement of *Paramecium* in the presence of obstacles. If time allows, the model will be completed with modeling of mechanical interactions between *Paramecium* and obstacles. Modeling results will be compared with behavioral experiments obtained at Laboratoire Jean Perrin with micro-engineered swimming pools with obstacles.

References

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