Biomimetic and bio-engineered shear stress sensor

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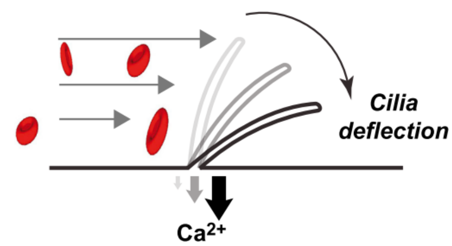
Context: To characterize a fluid flow, the simplest method is to measure the velocity field. But, in the case of complex fluids for which there is no constitutive law, the shear stress remains unknown. Tedious methods exist to measure the shear stress near a wall. They consist in complex micro-fabricated devices that cannot map the shear stress in volume. Here, we will follow a biomimetic approach. Flow sensors exist in biology: at the scale of micro-organisms like bioluminescent micro-algae or at the single-cell scale like the hair cells for hearing. The molecular mechanism for algae is not elucidated while the 3D structure of the hair cells is rather complex. Our model system will be the primary cilia (see figure) found on blood vessel endothelial cells. The cilia is a hair-like structure placed at the cell surface in contact with the blood. The cilia deflects when blood flow is present and triggers downstream signaling in the cell.



Protruding and highly sensitive primary cilia behave as flow sensors in blood flow. Flow-mediated cilia deflection allows calcium influx in the endothelium. Goetz et al. *Cell Reports*, 2014

Objective: The main goal of the project is **to create a shear stress sensor inspired from the biological primary cilia and engineered with biological components**.

The first step will consist in designing the artificial cilia with DNA origamis. DNA origamis make possible the nano-fabrication of self-assembled molecular structures. Introduced in 2006 (Rothemund, Nature 2006), the field is now open to non-specialists via dedicated softwares for designing the proper DNA sequences and calculating their mechanical properties. The trainee will calculate the deflection of a DNA origami beam under a shear flow and try with other designs so as to choose the best nanostructure. Some experimental tests can be conducted to design the detection method: Förster Resonance Energy Transfer or simple tracking. At the end of the internship, we will have the perfect candidate for a bio-engineered shear sensor. The following PhD thesis will be the implementation and characterization of the sensor and the demonstration in the context of turbulent and/or complex fluids. The ultimate goal is to adapt such sensors for shear stress measurements in volume.