

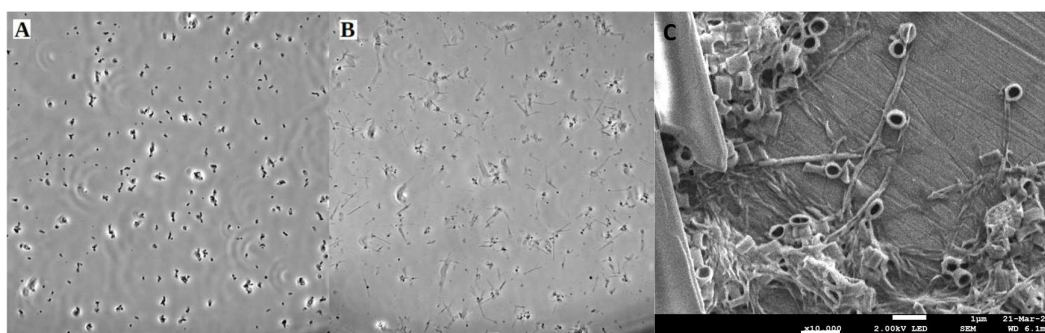
Extension and retraction of giant protein self-assemblies under shear

R-bodies are giant proteinaceous self-assemblies that have the remarkable ability to switch from a 500 nm-sized scroll into a 20 μm -long, sharp needle capable of puncturing membranes. They are assembled by the copolymerisation of four small proteins (RebA, RebB, RebC and RebD). Co-expression of these proteins in *E. coli* leads to the formation of functional R-bodies that can be readily purified by repeated sedimentation-and-wash cycles. R-bodies can extend and retract in response to modest pH changes: when the pH drops below 5.7, the scroll-form R-bodies extend into the needle form; they revert to the contracted state when the pH rises again. This behaviour also depends on the ionic strength of the solution. At high salt concentrations, the highest pH at which R-bodies are completely extended is ≈ 5.4 , whereas at very low ionic strength they remain fully extended up to $\text{pH} \approx 6.2$. The structures can undergo hundreds of extension-retraction cycles without any loss of their pH-responsive ability ^[1].

In this internship we will combine a microfluidic setup that can impose rapid pH changes with high-resolution phase-contrast microscopy to monitor extension and retraction cycles. Microfluidic devices are routinely used in biophysics and active-matter studies to investigate bacterial swimming; here we will follow R-bodies from their coiled state (a ribbon only 13 nm thick and 400 nm wide) to their fully extended state (a 10–20 μm -long needle). To elucidate the force balance underlying the extension mechanism and to quantify the forces involved, we will vary the shear stress applied to the sample and the viscosity of the surrounding medium. Using an optical-tweezer system, we will also measure the force generated by the extension of this giant protein assembly.

The ideal candidate should follow a master's degree in physics, materials science or biological physics, and will be talented, motivated, patient, and dedicated to establishing reproducible measurements. The internship is full-time in ICS Strasbourg for a period of 4–6 months. This project is part of a collaboration within the framework of the ITI-Hi Fun-Mat program, involving Laurent Pieuchot (biologist, IS2M Mulhouse) and Igor Kulic (theoretical physicist, ICS Strasbourg). A strong affinity for interdisciplinarity is therefore required.

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1: **A** 100X magnification Phase microscopy images of Rbodies in their contracted form in PBS buffer at pH 7.5. **B** . Exchanging PBS buffer with citrate buffer at pH 4.5 caused a rapid extension). The scale bar is 10 μm . **C** . Scanning Electron Microscopy image of RBodies showing their 2 different conformations.

[1] Polka, J. K. & Silver, P. A. A Tunable Protein Piston That Breaks Membranes to Release Encapsulated Cargo. *ACS Synth. Biol.* 5, 303–311 (2016).