Cell-Sized, Nano-Precise: Engineering Freeform DNA Megastructures using Crisscross Origami

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DNA origami is a unique technology that utilizes DNA not for its information storage capabilities, but for its favourable properties as a nanoscale construction material. By exploiting DNA's strict base-pairing rules, a designer can program hundreds of short ‘staple’ strands to fold a long DNA strand into a wide variety of shapes with nanometre precision. In just two decades since its inception, the technique has been used to build complex 3D nanoscale structures that incorporate macroscale engineering concepts such as rotating arms, motors and latches, with applications varying from photonic materials to targeted drug delivery vehicles.

However, DNA origami structures have always been limited in size to just a few hundred nanometres. Efforts to push this boundary have been frustrated by falling yields or excessive aggregation as off-target binding complicates the intended assembly pathway. In this talk, I will present the crisscross DNA origami technique, a hierarchical assembly method that, for the first time, allowed the creation of fully-addressable DNA ‘megastructures’ composed of hundreds to thousands of unique DNA origami monomers in structures exceeding 2μm in size. The seminar will focus on the assembly mechanism and manufacturing pipeline behind crisscross origami, before exploring how these cell-sized yet nanoscale-precise structures could provide a platform for new synthetic materials that interact directly with living cells.

Speaker Bio: Matthew Aquilina is a postdoctoral fellow in the William Shih Lab at the Wyss Institute at Harvard University and the Dana-Farber Cancer Institute. He started on his journey to becoming a molecular engineer at the University of Malta, where he earned a B.Eng. in Electrical/Electronic Engineering and built an autonomous smart wheelchair for his final thesis. From there, he studied for a Master’s in Artificial Intelligence at the University of Edinburgh, after which he continued on to obtain his PhD in Precision Medicine. During his PhD, he worked with DNA nanotechnology to design specialized biomarker diagnostic assays and machine learning-based gel analysis tools. His current research focuses on programmable DNA nanostructures, including crisscross DNA origami, and their use in synthetic cell-interfacing and immuno-engineering applications.