CiQUS Lectures

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Abstract:

Living self-organizing systems operate far-from-equilibrium and display energy-dependent functionalities that are orchestrated through feedback loops and metabolic reaction networks to allow response, adaptation and communication in complex sensory landscapes. A cell is a formidable example that exhibits the Sense-Process-Act paradigm to sense and translate external signals, process and memorize them using Boolean and non-Boolean Algebra using its internal signaling network and act based on this outcome in order to internally adapt or communicate to the surrounding. This allows phenotype changes and communication for emergence in tissue formation and for morphogenesis.

In this talk, I will discuss the formation of DNA-based protocell architectures using a recently discovered liquid-liquid phase separation process of ssDNA. Furthermore, I will show how secondary structures can be accessed inside as an artificial cytoskeleton, and that uptake of reactive species does not follow Fickian diffusion. Towards incorporation of a metabolism, I will reveal how abiotic catalysts and DNAzymes can be embedded within these artificial cells to drive downstream morphological adaptations.

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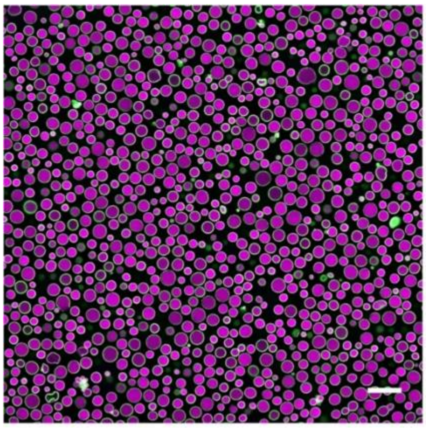

Selected References:

<u>Review</u>: AW "From Responsive to Adaptive and Interactive Materials and Materials Systems: A Roadmap" Adv. Mater. 1905111 (2020).

<u>Review</u>: RM, AW "Materials learning from life: Concepts for active, adaptive and autonomous molecular systems". Chem. Soc. Rev. 2017, 46, 5588;

<u>Original Works</u>: Nat. Nanotechnol. 1856 (2020); Nature Nanotech. 13, 730 (2018); Nat. Commun. 13, 1 (2022). Angew. Chem. Int. Ed. e202208951 (2022). J. Am. Chem. Soc. 145, 7090 (2023).

Biosketch:

Andreas Walther is a Gutenberg Research Professor and head of the "Life-Like Materials and Systems" lab at the University of Mainz in Germany. His research interests concentrate on developing and understanding hierarchical and metabolic self-assembly concepts inside and outside equilibrium, and on using them to create life-inspired materials systems with the capacity for active, adaptive and autonomous behavior. A. Walther is a two times ERC grantee, a founding PI of the DFG Cluster of Excellence *liv*MatS, a Max Planck Research Fellow, and a former Senior Fellow of the Freiburg and Strasbourg Institutes for Advanced Studies. He has published ca. 220 publications (h-index 69, ca. 19000 citations) and has been awarded the Bayer Early Excellence in Science Award (for Materials), the Reimund Stadler Young Investigator Award of the German Chemical Society, as well as the Hanwha-Total IUPAC Young Scientist Award awarded at the IUPAC World Polymer Congress.

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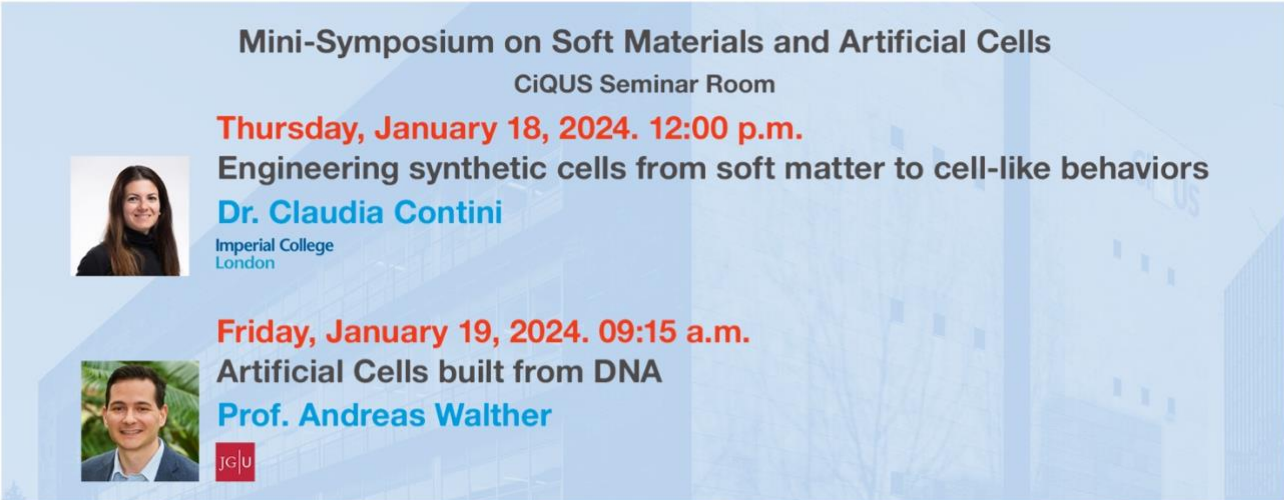

Dr. Claudia Contini
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Abstract:

Our cells are the most elaborated biological machine. They are continuously releasing and up taking billions of molecules in the environment, and they use this communication system to process information and act accordingly. However, manipulating and programming cells and understanding their intrinsic complexity is challenging as cells are often difficult to decode and manipulate.

My research involves the creation of artificial cell-like systems (protocells) from scratch by using synthetic or hybrid molecular building blocks, which are fully controllable by design and mimic the fundamental structure or mechanisms of natural cells. This multidisciplinary endeavour aims to create a broad range of products for functional applications and, at the same time, an increased understanding of biological systems and mechanisms. Among all the cellular processes and mechanisms, one of the most exciting open challenges in chemical engineering is the development of artificial cell-like systems capable of autonomous and directional motion in response to their environment and adapt to its changes. Realising an artificial motile life-like system, controlling its motion and understanding its spatiotemporal organisation mimicking the biological communication will actively advance our understanding of the origin of life and push the boundaries of scientific discovery. Engineering well-defined bespoke artificial cells from scratch that exhibit autonomous and directional motion in response to their environment, will pave the way for the application of artificial motile protocells in clinical and industrial settings. This opens up an entirely new research area with long-term ramifications and potential applications, for example, including: (i) artificial-cell devices that are powered by biocompatible and biological compounds; (ii) Intelligent and active delivery of therapeutics directly to a specific target site; (iii) artificial cells swimming to specific sites that require bioremediation; (iv) Controlled spatiotemporal self-organisation of motile artificial cells for the generation of artificial tissues and materials.

Biosketch:

Claudia Contini is a Lecturer in Biotechnology and Engineering Biology and BBSRC Discovery Fellow in the Department of Life Sciences at Imperial College London. Before this appointment, she was a L'Oréal-UNESCO UK Fellow and \issf Springboard Fellow at the same institution. She completed her undergraduate and master studies in pharmaceutical chemistry at the University of Padua in Italy before obtaining a PhD in physical chemistry at the University College London in 2017. Multiple awards have recognised her research, including the 'Italy Made Me' award from the Italian Ambassador in London to recognise her innovative research carried out in the UK. Her research focuses on engineering synthetic life-like systems that mimic biological properties and functions for biomedical applications.

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