

Molecular Protein-Tectons in Synthetic Biology and Nanotechnology: From the Functional Expansion of the Cell with *de novo* Organelles & Functional Modules to Biobased Nanosystems

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Life is embedded into a fascinating molecular complexity of dynamic structure & function forming processes we aim to understand and to control. The synthetic biology approach we use interprets synthetic biology as transformation and organization of molecules and molecular systems within complex systems creating new system properties structuring and functionalizing space. Thus, the synthetic biology approach in my group focuses on embedding new cross-compatible molecules & molecular networks as structural and functional modules for the functional expansion of the cell.

Taking a functional engineering approach we design a toolbox of biogenic tectons (tecton = architectural building block) on the DNA and protein level delivering these tectons as cellular building blocks and networks with regulatory and structural functions, which did not previously exist in nature.^{1,2}

Realizing such protein-based modular biological devices resembling a close systematic link to the so-called BioBricks, we design biogenic protein tectons within cells showing complex dynamic structure forming behavior, such as adjustable structured self-assembly of organelle-like NanoBioSystems.^{3,4}

These efforts are complemented by redesigning the translational networks of the cell expanding the functionality of the genetic code with xenobiotic elements such as unnatural amino acids further increasing the functional space of defined molecular protein modifications combining chemical and biosynthetic methods. An interesting approach in this context will be exemplified by the transformation of cofactors to prosthetic groups within enzymes and approaches to control the assembly of proteins towards enzyme cascades via protein switches and optogenetic tools.

By designing interacting protein architectures and implementing novel interaction systems on the nanoscale via bioorthogonally encoded chemical entities/signals we emulate the coexistence of several elements allowing for a functional expansion of the cell by molecular system design of our functional modules.

Implementing the controlled assembly of organic-inorganic nano-architectures we termed “protein adaptor-based nano-object assembly” (PABNOA)⁵ opens up new roads towards functional materials with new properties with molecular precision for possible applications in modulating molecular quantum phenomena e.g. in energy converting or harvesting systems *in vitro* and *in vivo*. The scalability of the molecular role for the transformation of matter and the conversion of energy in the context of *in vivo* and *in vitro* applications and their embedding into the natural material and energy cycle allows for a vast range of applications especially in the context of a sustainable bioeconomy.

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