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Three-Dimensional Protein Nanostructures

Proteins are remarkable molecules for use in both biological applications and as components of advanced functional materials. While proteins have been used in nanotechnology to yield highly symmetric assemblies such as cages, fibers or sheets, as of now, it is not possible to use them to create arbitrarily complex nanoassemblies. Unlike DNA, proteins don't have Watson-crick pairing which allows for the construction of highly anisotropic, programmable, user-specified nanostructures.

Inventors

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Professor Nicholas Stephanopoulos at the Biodesign Institute of Arizona State University has developed a portfolio of technologies for building highly addressable, anisotropic, and user-defined protein-based nanostructures. Monomeric protein building blocks are chemically modified with unique addressable handles which enable them to be precisely positioned on a scaffold. After arranging multiple protein nanostructures to create the desired 3D object, the protein nanostructures are crosslinked. The protein nanostructures can be removed from the scaffold leaving behind a purely-protein based structure, which can be folded into more complex 2D and 3D shapes. Because each protein nanostructure building block can be unique, the final 3D nanostructure will have the addressability and anisotropy of DNA nanostructures, but with all the chemical and biological advantages of proteins.

These technologies lay the foundation for a new paradigm in protein nanotechnology and open up the possibilities for novel all-protein nanostructures.

Potential Applications

- Novel or hyperstable biomaterials
- Targeting devices/cages
- Biosensors – multitude of applications
- Therapeutics – artificial vaccines and antibodies, etc.
- Molecular nanomachines

    - Can be activated by protein conformational switching
- Templates for inorganic nanoparticles
- Synthetic ion channels
- Cell-mimetic system (e.g. molecular factories)

Benefits and Advantages

- The final 3D object has addressability and anisotropy
- Has all the chemical and biological advantages of proteins (including the ability to fuse enzymes or other functional modules to them)
- All-protein assemblies, not hybrid structures
- Greater diversity of protein-based building blocks
- Incredibly stable and resistant to degradation
    - Enhanced utility in biological and non-biological applications, including elevated temperature, low-salt, and potentially organic solvents

For more information about the inventor(s) and their research, please see

Dr. Stephanopoulos' Biodesign webpage

Dr. Stephanopoulos' laboratory webpage