

Learning from Nature How to Build Beautiful Structures from Protein Molecules

Nanotechnology researchers in the last decades have sought to fabricate materials with control at finer and finer scales, reaching well below the micron range. At the same time, efforts by structural biologists have revealed the detailed atomic shapes of thousands of macromolecules evolved by nature, some of extraordinary sophistication and beauty. Intersections between these two areas of scientific investigation have motivated diverse strategies for trying to create novel molecular architectures similar to those found in nature, with control at the nanometer scale. The two ultimate goals of such endeavors are to better understand natural phenomena from biophysics to evolution, and to use that understanding to create nanoscale materials with novel functionalities not realized before by nature. Considerable early successes in building with biological molecules came from using DNA as the building block. The rules governing DNA structure are simple enough to enable diverse assemblies to be designed, but DNA molecules offer somewhat limited chemical functionality. In contrast, protein molecules offer exception versatility in terms of chemistry and biological reactivity, but the rules that govern their folding and assembly are not completely understood. General strategies for building with protein building blocks has therefore been a high value goal, with considerable technical challenges. Taking lessons from the symmetry in natural protein assemblies, successful strategies have been demonstrated for designing novel geometric architectures like protein cages in the shapes of cubes and other Platonic solids, as well as extended materials with long-range order. Such designed structures are enabling numerous applications in nanotechnology and medicine. This talk will cover the underlying principles that eventually led to success, along with a discussion of some of the obstacles encountered, and remaining challenges that must be met before routine application of the technologies is possible.