Biologically Based Assemblies of Electronic Materials at the Nanoscale; Improving on Nature

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Biological systems efficiently and accurately assemble nanoscale building blocks into complex and functionally sophisticated structures with high perfection, controlled size and compositional uniformity. The self-organizing processes found in these systems rely largely on non-covalent interactions that enable elegant rearrangement between usable architectural forms and self-correction. The research will take advantage of the atomic composition and plane specific recognition that a biomolecule can exhibit for an inorganic phase, and the nanostructural control and regularity that biomolecules typically impose on crystal phases and crystallographic orientations to control nanostructure formation. Furthermore, RNA templates will be used to direct the parallel self-assembly of multiple electronic components with high precision. Using combinatorial peptide evolution, peptide sequences will be identified that select for and bind to specific nanocrystal and nanowire substrates, such as magnetic and semiconductor quantum dots and silicon nanowires synthesized in solution. The peptides provide recognition specificity between the biological molecules and the inorganic substrate. The peptides couple the inorganic electronic "building blocks" to the biological machinery that directs the architectural "blueprints" for organization. In essence, genetically encoding biological-electronic interactions are selecting the mRNA sequences that code for specific amino acid sequences, but beyond that, specific secondary and ultimately tertiary structures can be achieved; thus, leading to supermolecular architectures.

An interdisciplinary effort will include synthetic chemistry, electrical and materials engineering, and molecular biology, which targets the development of specific recognition chemistries between biological and inorganic substrates for the creation of nanostructured materials and devices with novel applications. The proposed project offers highly interdisciplinary educational and research opportunities for graduate students.