PREFACE

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PREFACE

Nanobiology: from physics and engineering to biology

Guest Editors

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Biological systems are inherently nano in scale. Unlike nanotechnology, nanobiology is characterized by the interplay between physics, materials science, synthetic organic chemistry, engineering and biology. Nanobiology is a new discipline, with the potential of revolutionizing medicine: it combines the tools, ideas and materials of nanoscience and biology; it addresses biological problems that can be studied and solved by nanotechnology; it devises ways to construct molecular devices using biomacromolecules; and it attempts to build molecular machines utilizing concepts seen in nature. Its ultimate aim is to be able to predictably manipulate these, tailoring them to specified needs. Nanobiology targets biological systems and uses biomacromolecules. Hence, on the one hand, nanobiology is seemingly constrained in its scope as compared to general nanotechnology. Yet the amazing intricacy of biological systems, their complexity, and the richness of the shapes and properties provided by the biological polymers, enrich nanobiology. Targeting biological systems entails comprehension of how they work and the ability to use their components in design. From the physical standpoint, ultimately, if we are to understand biology we need to learn how to apply physical principles to figure out how these systems actually work. The goal of nanobiology is to assist in probing these systems at the appropriate length scale, heralding a new era in the biological, physical and chemical sciences.

Biology is increasingly asking quantitative questions. Quantitation is essential if we are to understand how the cell works, and the details of its regulation. The physical sciences provide tools and strategies to obtain accurate measurements and simulate the information to allow comprehension of the processes. Nanobiology is at the interface of the physical and the biological sciences. Biology offers to the physical sciences fascinating problems, sophisticated systems and a rich repertoire of shapes and materials. Inspection of the protein structure databank illustrates the breadth of scaffolds, shapes and properties that protein molecules and their building blocks can provide. Via a shape-guided self-assembly strategy, these can be put together toward a specific function. Further, by inserting synthetic non-natural residues at judiciously selected positions, or synthetic peptide linkers, we may selectively rigidify the construct, or obtain a totally new world of shapes and scaffolds. Such broadening of the chemical space may lead to an almost unlimited range of nanosystems and architectures.

Merging computation with experiment will accelerate nanodesign. Computational modeling will enhance the application of nanotechnology to key areas such as drug delivery and biomaterial design. Nanobiology is a field where interdisciplinary collaborations are essential and disciplines converge. Discipline convergence should enable the quantitation, leading to a better understanding of the regulatory networks within cells and between cells of an organism. These networks dictate how a cell responds to external stimuli, which in turn activate signaling cascades. It should allow the addressing of a broad range of questions on the structure and function of the cytoskeleton; the nuclear envelope; signal transduction by membrane embedded receptors; the nanomechanical properties of the extracellular matrix; nuclear transport; and voltage induced channel gating.

For successful nanostructure design, we need to figure out and be able to control the intermolecular associations. For a stable functional construct, there are two key elements: first, the conformations of the building blocks in the designed structure should follow their natural tendencies; and second, the associations should be favorable. Molecules interact through their surfaces. Thus, favorable associations derive from shape complementarity and contributions of the various physical components.

Nanobiology is in its infancy. Yet, biology provides an enormous range of engaging and stimulating problems with many *in vivo* examples of intricate, complex, fascinating biological systems. Understanding, mimicking and controlling the devices which target these processes and which are constructed from these molecules is a tremendous challenge to the converging disciplines in nanobiology.