Grand Challenge: Dynamic Self-Assembling Systems

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Dynamic self-assembling systems, those that develop local spatial and temporal organization to perform time-dependent tasks, are widely prevalent in nature. For example, the biological membrane, a 7-9 nm thick bimolecular layer, is a multi-component complex fluid composed of a phospholipid matrix phase with a number of secondary functional components including glycolipids and ion channels. Depending on the needs of the cell and the stimuli present in the extracellular environment, the membrane can perform a variety of complex, time-dependent functions including active and passive ion transport, molecular recognition, and energy transduction. The fluid nature of the membrane allows molecules embedded within the membrane to migrate, undergo conformational changes, and self-organize as needed to perform these tasks.

Realizing dynamic self-assembly in engineered nanosystems is a grand challenge. In contrast to the dynamic behavior of biological nanosystems, virtually all engineered nanosystems have a static structure. Developing sensors and actuators based on materials that can be reversibly reconfigured at the nanoscale clearly has tremendous promise. Materials which exhibit the characteristics of both solids and liquids, such as membranes, liquid crystals, and colloids (collectively known as soft matter) have the potential to realize such self-organizing nanostructures. Practical development of sensors and actuators based on this approach will require a broad interdisciplinary approach combining mechanical and electrical engineering with the fundamental sciences of biology, physics, and chemistry.