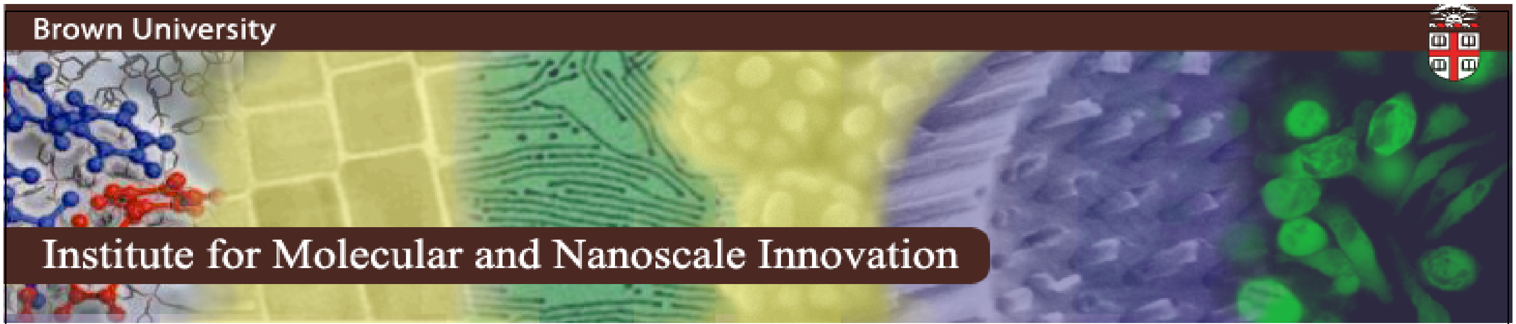

”Micro-Engineering Osmotic Stresses in Colloidal Dispersions and Synthetic Trees”

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Osmotic stresses can play a central role in defining the properties of soft materials. For example, biology exploits these stresses to direct the formation of structure (e.g., rouleaux in blood), to define mechanical properties of tissues (e.g., cartilage), and to control function (e.g., management of water in vascular plants). These sophisticated uses of osmosis rely on structural heterogeneity to localize the sites of osmotic equilibria and to direct the resultant stresses. In this talk, I will discuss fundamental and practical considerations for analogous implementations of osmotic stresses in synthetic systems. I will illustrate these points with two experimental studies in which we have micro-engineered osmotic forces to control the behavior of lithographically structured soft materials: 1) Shape-directed colloidal assembly. I will review the well-established concept that osmotic stresses lead to attractive interactions between colloids dispersed in solutions of a non-adsorbing polymer, and I will point to the less explored use of this depletion interaction as a selective and directional “osmotic bond” between non-spherical particles. Employing lithographically defined particles, I will illustrate the necessary conditions that make the use of this phenomenon practical and demonstrate its use to direct self assembly and to probe surface forces. 2) Transpiration in Synthetic Trees. I will introduce a minimalist representation of the transpiration machinery in vascular plants (root membrane – xylem – leaf membrane) as an osmotically coupled network. I will describe our experimental realization of this system as a microfluidic network formed entirely within a synthetic hydrogel. With this “synthetic tree”, I will demonstrate the generation of large osmotic *tensions* (osmotic pressures < -100 atms) in water and our use of these tensions to explore the limit of stability of liquid water at negative pressures, to pump along gradients in tension, and to reverse osmosis “purify” liquid water from sub-saturated vapors. I will finish with perspectives on technological implications of these studies and how they can inform our understanding of physiological design in plants and mammals.

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