DEPARTMENT OF

CHEMISTRY

UNIVERSITY OF NEBRASKA-LINCOLN

SPRING 2014 CHEMISTRY COLLOQUIA

Dr. Jim De Yoreo
Pacific Northwest National Laboratory

April 18, 2014

2:45 Reception
3:00 Seminar
112 Hamilton Hall

Co-sponsored by CNFM

"Physical Insights into Nature's Way of Making Materials"

Self-assembly of protein matrices and subsequent mineralization is a widespread paradigm in the biological production of hard materials. The architecture of the underlying matrix imposes order on the nucleating mineral phase. The resulting structural complexity and mechanical properties are unparalleled in current synthetic approaches. Moreover, the vast amount of carbonate mineralization carried out by marine organisms impacts global seawater chemistry and maintains the largest terrestrial reservoir of CO_2. Thus matrix assembly and mineralization impact human health and the environment, and are an inspiration to materials scientists. To understand the underlying physical controls governing matrix assembly and mineralization, we have investigated these processes using *in situ* AFM and TEM combined with dynamic force spectroscopy (DFS) and molecular dynamics.

Our results reveal the key role played by conformational transformations in controlling the pathways and kinetics of matrix assembly. Moreover, the pathway to the final ordered state often passes through transient, less-ordered conformational states. Thus the concept of a folding funnel with kinetic traps used to describe protein folding is also applicable to matrix self-assembly. Analysis of matrix mineralization shows that nucleation is promoted through a reduction in the interfacial energy. However, nucleation via an amorphous precursor is observed at supersaturations that are too low to be explained by classical theory. The existence of pre-nucleation clusters is shown to provide a low-barrier pathway to crystallization that circumvents the large barriers to nucleation. Finally, *in situ* TEM shows that particle-mediated growth processes commonly observed in biomineral and biomimetic systems are driven by a highly orientation-specific interaction that acts over 1 nm distances and results in attachment accompanied by crystallographic alignment. Taken together, these results provide new insights into the mechanisms controlling biological crystallization, from formation of the initial matrix to the maturation of final crystalline structures.

University of Nebraska Lincoln | COLLEGE OF ARTS & SCIENCES