Knowledge of molecular-scale interactions is central to understanding reactivity, energy, and dynamics in chemical systems for both novices and experts. Exploration of molecular-scale interactions is a theme that is common to Dr. Posey’s research in chemical education and experimental physical chemistry.

A Developmental Chemistry Curriculum for Underprepared Students
In 2012, the President’s Council of Advisors on Science and Technology (PCAST) reported that one million additional college graduates with STEM degrees would be needed over the next 10 years to meet the anticipated demand for technically skilled workers. Unfortunately, many students interested in pursuing STEM careers enter college without the background and skills required to succeed in general chemistry, which is typically the first of the gateway science courses required for STEM degree programs. In fact, under 40% of the students who enter college as STEM majors graduate with a STEM degree. We are investigating a new approach to prepare students for STEM majors’ general chemistry courses that is based on learning progressions for three core ideas in chemistry: 1) structure and properties of matter, 2) chemical and physical transformations, and 3) energy and electrical interactions. Learning progressions describe possible pathways to increasingly complex and scientifically correct understanding within a domain. Learning progressions are grounded in what is known about learning as a developmental process; they carefully scaffold student learning on existing knowledge to build understanding that is transferrable and robust. Instructional materials under development will blend science practices (models, scientific explanations, argumentation, and mathematical thinking) with the core ideas developed in the three learning progressions.

Slow Protein Dynamics
Proteins exhibit richly textured energy landscapes near the native fold with barriers that can be surmounted by structural fluctuations at physiological temperatures. Numerous low-energy barriers near the native fold result in an ensemble of conformational states with equilibrium fluctuations posited to play a significant role in both biological function and creation of the misfolded states implicated in diseases including Alzheimer’s, Parkinson’s, Creutzfeldt-Jakob, and bovine spongiform encephalopathy. Many of the dynamic processes in proteins that are relevant to biological function and misfolding involve collective, large-amplitude motions that occur on relatively long timescales (μs and longer). The long-lived triplet states responsible for phosphorescence emission permit us to extend the time window for electronic emission spectroscopy to a time regime that is relevant to physiologically important slow protein motions. We have demonstrated that time-resolved phosphorescence spectroscopy and the phosphorescence dynamic Stokes shift can be used to characterize timescales for large-amplitude motions near the native fold in proteins. This approach is being used to measure barrier heights near the native fold and to study the influence of the hydration layer on protein dynamics.

Selected Publications


Time-resolved phosphorescence spectra from ZnII-substituted cytochrome c exhibit a dynamic Stokes shift response arising from protein dynamics on the μs timescale.