In the past five years there has been an explosion of research activity involving the formation and physics of cold molecules. Our collaborative research team at UConn has focused largely on photoassociation, in which a laser assembles a pair of already cold alkali atoms to form an electronically excited diatomic molecule. Subsequently radiative decay produces stable molecules at temperatures well below 1 mK. I will describe new techniques for efficiently forming molecules in selected vibrational levels of the ground state and the metastable lowest triplet state, then using these molecules to study novel physics.

Unfortunately, most atoms cannot easily be laser cooled to allow photoassociation. An alternative approach is to extend the use of direct laser slowing from atoms to molecules, and a few successful efforts have very recently been reported. I will briefly describe a new project in which we will use the optical bichromatic force to augment conventional radiative forces. It relies on coherent momentum cycling in two-color laser fields to produce extremely large decelerations. A successful decelerator for metastable atomic helium is operating in our lab, and a new version for CaF molecules is under construction.