Crystal engineering is a broad area of research that focuses on methods of designing and/or optimizing materials for diverse applications in fields spanning energy to biomedicine. The ability to selectively control crystallization to achieve desired physicochemical properties requires detailed understandings of the thermodynamic and kinetic factors regulating crystal nucleation and growth. Combining this fundamental knowledge with innovative approaches to tailor structural outcomes has the capability of producing materials with superior properties beyond what is achievable by conventional routes. Nature provides numerous examples to inspire rational design of synthetic crystals. A ubiquitous mechanism to control crystal growth is the use of modifiers (also termed inhibitors), which are molecules that interact with specific surfaces of crystals and regulate anisotropic growth rates. In this talk, I will show how we use growth modifiers to control crystallization in two distinctly different, yet fundamentally similar, research areas. In the first part of my talk, I will discuss our work on the development of therapeutic drugs for pathological and infectious diseases, focusing primarily on the design of peptide inhibitors of calcium oxalate monohydrate, the most prevalent constituent of human kidney stones. In the second part of my talk, I will discuss how we are using modifiers as a bio-inspired approach to tailor the properties of zeolites, which are microporous materials utilized in many commercial processes (e.g. catalysis and ion-exchange). Our group employs zeolite growth modifiers (ZGMs) to selectively tune crystal size, morphology, and surface architecture. I will discuss how we select ZGMs and characterize their efficacy and specificity using techniques that probe macroscopic to molecular scales. I will also emphasize the benefits of this facile approach for catalytic applications in fuels and chemicals, and discuss its broader applicability for the synthesis of other materials.