Non-covalent interactions involving aromatic rings (π-stacking interactions, anion/π interactions, XH/π interactions, etc.) are vital for myriad aspects of modern chemistry, playing central roles in everything from the packing of materials in the solid state and the binding of ligands by proteins to controlling the stereoselectivity of organocatalyzed reactions. Despite their importance, our understanding of these interactions is largely incomplete. I will discuss our efforts to understand the nature of these interactions and the means by which we can tune their strength. The primary focus will be on substituent effects in π-stacking interactions, although I will also discuss our recent work concerning the nature of anion/π interactions involving N-heterocycles.

Ultimately, I will show that conventional models of substituent and heteroatom effects on many non-covalent interactions involving aromatic rings are not supported by recent computational and experimental data. I will offer a simple, alternative predictive model of these interactions. For example, I will show that substituent effects in π-stacking interactions can be described based on the local, direct interactions between the substituents and the other ring. There is no need to invoke substituent-induced changes in the π-electron-system of the substituted ring to describe these substituent effects. Similarly, favorable anion/π interactions between simple anions and N-heterocycles (pyridine, pyrazine, s-triazine, etc) arise almost entirely from interactions of the anion with the σ-system of the ring, not the n-system.