To streamline the synthesis of functionalized molecules, our laboratory has pursued the development of novel transformations that employ oximes and hydroxamic acids. We have discovered conditions to unlock and control the reactivity embedded in the N–O bond to achieve a diverse array of new reactions and to efficiently prepare challenging C–O, C–N, and C–C bonds from simple starting materials. We have also discovered that oximes can undergo C–N bond coupling to access ketonitrone that are inaccessible using existing synthetic technology. We have triggered efficient cascade processes using these compounds to regio- and stereoselectively access important heterocycles. The scope and limitations of these new methods will be discussed in addition to experiments designed to explore the mechanisms of these processes.