Our bodies contain amazing molecular machines whose function is programmed into the molecules themselves—RNA or protein sequences that encode the ability to synthesize molecules, haul cargo, and regulate development and repair. It is these remarkable biological proofs-of-principle that inspire the nascent field of molecular programming. This talk will describe mechanisms and principles for engineering nucleic acid devices that execute diverse dynamic functions. Experimental results will feature synthetic molecular systems engineered to address longstanding challenges in biological imaging and therapeutic regulation.