We are investigating photoinduced electron tunneling reactions to deeply buried active sites in cytochrome P450s, copper amine oxidases, and nitric oxide synthases (NOS) in conjugates with Ru(II)-diimine and Re(I)-diimine wires that reveal functionally relevant structural features of these enzymes. Ultrafast electron transfer to the heme in inducible NOS occurs upon excitation of an imidazole-terminated Re(I) fluorinated biphenyl wire bound tightly in the active site channel. The first step in the mechanism may involve reductive quenching of electronically excited Re(I) by a nearby tryptophan. We also are investigating the roles of aromatic amino acids in promoting distant charge transport in selected mutants of Pseudomonas aeruginosa azurin. We have found a greatly enhanced electron transfer rate from Cu(I) to electronically excited Re(I) bound to histidine-124 that we suspect is attributable to uphill hopping through an intervening tryptophan-122 on the methionine-121 beta strand, as coupled electron tunneling events with endergonic steps can in principle deliver electrons or holes much more rapidly than single-step tunneling reactions. Requirements for functional hopping include optimal positioning of redox centers and fine-tuning of reaction driving forces. We are testing electron and hole hopping computational models in kinetics experiments employing azurin mutants in which chemically modified tyrosines are positioned between Cu(I) and photogenerated Ru(III)-polypyridyl oxidants on the cysteine-112 and methionine-121 beta strands.