Proton-coupled electron transfer (PCET) reactions play an important role in a wide range of energy conversion processes. This talk will present theoretical approaches for simulating the ultrafast dynamics of photoinduced PCET with either a dielectric continuum or an explicit molecular representation of the solvent. In the dielectric continuum solvent representation, an ensemble of nonadiabatic surface hopping trajectories is propagated with Langevin dynamics on electron-proton vibronic free energy surfaces that depend on two collective solvent coordinates. In the explicit solvent representation, the surface hopping trajectories are propagated with Newtonian dynamics on multidimensional electron-proton potential energy surfaces that are calculated on-the-fly with a multistate empirical valence bond potential. Applications of these approaches to model systems illustrate both sequential and concerted mechanisms, as well as more complex branching processes involving a combination of sequential and concerted mechanisms. These applications also provide insights into the roles of proton vibrational relaxation and nonequilibrium solvent dynamics in photoinduced PCET processes. In addition, these calculations provide an explanation for the experimental observation of the onset of a deuterium isotope effect only after an initial fast decay for PCET in double-stranded DNA and methanol adsorbed on titanium dioxide surfaces.