X-ray emission from accreting binary systems (X-ray binaries) provides a unique signature of the binary phase of stellar evolution and compact object populations (neutron stars and black holes). Through detailed X-ray and multiwavelength observations (e.g., from Chandra, Hubble, Spitzer, and other telescopes) of both nearby and distant galaxies, I am working on obtaining a more complete picture of how stars and compact objects formed and evolved throughout the history of the Universe. I will present ongoing and planned observational efforts to characterize (1) how the formation of X-ray binary populations in nearby galaxies is linked to the physical properties of the galaxies themselves (e.g., galaxy morphology, star-formation activity, stellar mass, stellar age, and metallicity); and (2) how X-ray binary populations evolved over the last 12 billion years of cosmic history (since z ~4) in response to significant changes in the physical properties of their host galaxies. I will highlight how forthcoming and archival observations, future multiwavelength telescopes, and binary population synthesis modeling will provide a powerful blend of resources for improving our understanding of X-ray binaries and compact objects.