Selenium and arsenic are intriguing elements: Se is an essential trace element, but toxic in excess, while As is one of the most toxic elements. Although generally present in the environment at low levels, Se and As are actively metabolized by microorganisms. These transformations modulate the toxicity of these elements and change their mobility and bioavailability, which in turn affect their translocation and accumulation in plants and hence, the nutritional quality of crops. The reduction of Se and As oxyanions for energy conservation is well established and now shown to be widespread in bacteria and archaea. Over the past decade, several novel microbes have been cultivated that respire Se and As oxyanions, including *Desulfurispirillum indicum, Seleniivibrio woodruffii,Pelobacter seleniigenes* and *Sedimenticola selenatireducens,* and new species continue to be discovered. We seek to elucidate the key drivers that affect the activity of Se- and As-respiring microorganisms; characterize their physiology to better understand what controls their activity; and demonstrate how in situ conditions regulate their activity. Specifically, our aim is to gain an understanding of the interplay of microbial redox processes contribute to the biogeochemical cycling of Se and As in the environment.