Living on arsenic and selenium

Lucian C. Staicu

Faculty of Biology, University of Warsaw, ul. Miecznikowa 1, 02-096 Warsaw, Poland (staicu@biol.uw.edu.pl)

Under anaerobic conditions bacteria possessing specialized respiratory pathways can use arsenic (As) and selenium (Se) to generate cellular energy and sustain growth and survival [1]. As and Se share common chemical properties and have a complex relationship with bacteria which act as a key component in the biogeochemical cycling of the two elements. Bacteria generate energy (ATP) through respiration by coupling the oxidation of an electron donor (organic or inorganic) with the reduction of the electron acceptor (in this case, the oxyanions of arsenic and selenium). Interestingly, certain bacterial strains can utilize numerous combinations of e-donors and e-acceptors, thus showing broad range metabolic repertoire and complex evolutionary scenarios. In contrast, certain strains can only use a limited range of compounds for respiratory processes, being restricted to environments with well-defined characteristics. The use of As and Se compounds for anaerobic respiration in bacteria started to be acknowledged at the end of the 1980s, while the full exploration of such processes (thermodynamics, enzymology and genetic determinants) emerged in the last decade of the 20th century and continues to this day. Both arsenic and selenium respiration appear to have had a major importance for bacteria during the ancient geologic periods when oxygen was present in very low concentrations in the atmosphere. Contemporarily, certain geological and industrial settings (e.g. ancient gold mine in Złoty Stok, Poland), as well as terrestrial and aquatic (e.g. Mono Lake, California) ecosystems favor the presence of As and Se in considerable concentrations [2]. In such contexts, bacteria still rely heavily of these elements to ensure proper metabolic functions, growth, and reproduction, and, in turn, contribute to the sustainability of such fragile ecosystems. The presentation will explore the fundamentals of As and Se respiration in phylogenetically-diverse bacteria and the potential use of such processes for biotechnological applications (recovery of nanoparticles from industrial effluents and bioremediation of arsenic- and selenium-laden wastewater) [3].

References

[1] Stolz JF, Basu P, Santini JM, Oremland RS (2006) Arsenic and selenium in microbial metabolism. Annu Rev Microbiol 60:107-130.

[2] Staicu LC, Oremland RS, Tobe R, Mihara H (2017) Bacteria vs. selenium: A view from the inside out. In: “Selenium in plants”, Eds. Pilon-Smits EAH, Winkel L, Lin ZQ, Springer, pp. 79-108.

[3] Cordoba P, Staicu LC (2018) Flue Gas Desulfurization effluents: an unexploited selenium resource. Fuel 223, 268-276.