The molecular response of *Deinococcus radiodurans* to real and simulated outer space environment

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Abstract:
Up to this date no definitive evidence for extra-terrestrial life has been found. However, the search fascinates mankind and it is very likely that one of the >2300 identified, habitable exoplanets (April 2018) may host a yet unknown kind of. It can be anticipated that our solar system harbours celestial bodies with living organisms apart from Earth and furthermore an interplanetary transfer of life exists. The Tanpopo orbital mission performs a long-term space exposure of microorganisms in order to validate the panspermia theory — the possible transfer of life between Earth and extra-terrestrial bodies. During such an interplanetary journey microorganisms have to survive under the harsh conditions of outer space. To test if microorganisms can withstand outer space environment for a longer period, the international space station (ISS) provides a suitable test facility. Within the Tanpopo space mission, several *Deinococcus spp.* have been selected for one to three years exposure outside the ISS, as these polyextremophiles are extremely resistant to ionizing radiation, UV radiation, oxidation stress and desiccation. We have applied an integrative –omics approach including transcriptomics, proteomics and metabolomics on *Deinococcus radiodurans* returned to Earth after a long-term space exposure and exposed to simulated space conditions. The combination of several –omics techniques and subsequent multivariate and univariate statistics are powerful tools to unravel molecular key regulators which are used by *D. radiodurans* to survive outer space exposure. It is broadly accepted that *D. radiodurans* uses manganese-orthophosphate-small molecule complexes to protect its proteins from oxidative damage, which is caused by environmental conditions like desiccation or irradiation. Our studies unravel the early response to outer space conditions of *D. radiodurans* after re-cultivation in a complex medium, emphasizing the differences on mRNA, protein and metabolite levels. The comprehensive combination of several –omics techniques in molecular analysis of *D. radiodurans* after real and simulated outer space conditions reveals that the molecular response is a multilayer process, which involves multiple rearrangements of energy metabolism, stress and DNA damage responses coordinated on the level of specific transcriptional regulators.