Quest for Microorganisms Existing at High Atmosphere and Space. S. Yokobori[1] (yokobori @ls.toyaku.ac.jp), Y. Yang,[1] T. Sugino,[1] Y. Kawaguchi,[1] S. Itahashi,[1] K. Fujisaki,[2] H. Fushimi,[2] S. Hasegawa,[3] H. Hashimoto,[3] N. Hayashi,[4] E. Imai,[5] T. Itoh,[6] H. Kawai,[7] K. Kobayashi,[2] K. Marumo,[8] H. Mita,[9] K. Nakagawa,[10] I. Narumi,[11] K. Okudaira,[12] H. Shimada,[1] M. Tabata,[3] Y. Takahashi,[13] H. Yabuta,[14] M. Yamashita,[3] H. Yano,[3] S. Yoshida,[15] Y. Yoshimura,[16] and A. Yamagishi[1],
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Microorganisms at high altitude have been collected using balloons, aircraft and meteorological rockets since 1936 [1]. Spore forming fungi and Bacilli, and Micrococci (probably Deinococci) have been isolated in these experiments. These spores and Deinococci are known by their extremely high resistance against UV, gamma ray, and dessication. If microorganisms could be found present even at the higher altitude, such as low earth orbit (400 km), the fact would endorse the possibe interplanetary migration of terrestrial life.

On the other hand, life on Earth emerged within a short period after the end of heavy bombardment, Panspermia hypothesis was proposed (e.g. [2-3]). Recent findings of the Martian meteorite suggested possible existence of extraterrestrial life, and interplanetary migration of life as well. Possiblity of interplanetary migration has been addressed by several other researchers (e.g. [4-6]).

We have collected microorganisms at high altitude by using airplanes and balloons. We isolated two novel species of the genus *Deinococcus*, one from top of troposphere (*D. aerius*) and the other from bottom of stratosphere (*D. aentherius*) [7-9]. These two species showed high resistance comparable to *D. radiodurans* R1 to UV and ionizing radiation such as gamma ray. In addition, we have obtained four isolates of spore-forming bacteria from stratosphere, including spore-formers such as *Bacillus pumilus* [10].

Can these newly isolated bacterial species and strains survive harsher environment such as space environment and/or other astronomical objects such as Mars? To address these questions, we have analyzed the survival of these microbial species and strains under the extreme conditions.

Environment at high altitude is extreme for microorganisms not only because of high UV radiation, but also other stresses such as extreme dryness. To clarify how dryness affects to the survivability of microorganisms, we examined the effects of desiccation and high humidity on survival and DNA double strand breaks (DSB) of *Escherichia coli*, *D. radiodurans* and spores of *B. pumilus* at 25, 4 and –70°C [11]. They exhibited different survival rates and DSB patterns under desiccation and high humidity. Higher survival and less DSB occurred at lower temperatures. Spores of *B. pumilus* showed the highest survivability at each condition. Survivability of *D. radiodurans* at desiccation condition is higher than that at the humid condition, although survivability of *E. coli* at desiccation condition is lower than that at the humid condition. In addition, *D. aerius* and *D. aetherius* also showed high survivability under the desiccation condition [1].

We also tested the effects of various factors (vucuum, heavy ions, heat cycle, etc.) on survivability of *Deinococcus* spp. Together with tests under desiccation condition, these test results suggested that *Deinococcus* spp. which we tested can survive in space for years.

We have proposed a mission named "Tanpopo", Japanese name of dandelion. This mission was proposed to examine possibility of interplanetary migration of microbes, and organic compounds on Japan Experimental Module (JEM) of the International Space Station (ISS). We are planning to capture microparticles at the ISS altitude by using ultra low-density aerogel [12].

In addition to particle-capture experiment on ISS, we also proposed exposure experiments of microorganisms and organic compounds with/without model-clay materials that might protect microorganisms and organic compounds from vacuum UV and cosmic rays. Spore of *Bacillus* spp., and vegetative cells of *D. radiodurans* and our novel deinococcal species isolated from high altitude are candidate for the exposure experiment. Amino acids and complex organic compounds that can be formed in space are also planned to be exposed.

References

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