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BIOLOGICAL CHALLENGES OF TRUE SPACE SETTLEMENT

Abstract

"Space Settlements" – i.e., permanent human communities beyond Earth's biosphere – have been discussed within the space advocacy community since the 1970s. Now, with the end of the International Space Station (ISS) program fast approaching (planned for 2024) and the advent of low cost Earth-to-orbit (ETO) transportation appearing to be likely in the near future, the concept is coming once more into mainstream. Considerable attention has been focused on various issues associated with the engineering and human health considerations of space settlement such as artificial gravity and radiation shielding. However, relatively little attention has been given to the biological implications of a truly self-sufficient space settlement. A settlement must involve long-duration, biologically self-sustaining human habitation. A settlement must involve more or less conventional agriculture. The systems of a settlement (engineering, biological, human) must be self-sufficient and able to recover from problems with no more than locally achievable human intervention. Breathable air and potable water must be available indefinitely, minimum nutrition must be created locally, and most important: there must be children with viability over time. There are a number of biological thresholds that must be considered for a self-sustaining space settlement: (1) essential flora, fungi and fauna (e.g., molds, microbes, insects, etc.) to create viable soil, (2) internal microbiota population required within healthy humans, (3) viruses and bacterial populations needed to keep human and animal populations immune systems strong, and (4) measures to ensure genetic diversity in both human, animal, plant, etc. populations (i.e., the "Noah's Ark" problem). And, the available resources in space must be examined and a determination made as to what must be imported from Earth. The microbiota within the human stomach are particularly important. Lastly, species brought to the settlement will have a minimum required number of individuals that are to ensure there is no inbreeding. One must consider each species individually.

Three fundamental questions are explored in this paper: (1) what are the biological implications of truly self-sufficient space settlements in the foreseeable future, (2) what is the minimum scale for such self-sustaining human settlements, and (3) what are the integrated biologically-driven requirements for such settlements? The paper examines briefly the implications of the answers to these questions in relevant potential settings (including free space, the Moon and Mars). Finally, this paper suggests relevant directions for future research and development in order for such space settlements to become viable in the future.