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LIFE SCIENCE BEYOND EARTH: EXPLORING THE LEGAL LANDSCAPE IN OUTER SPACE EXPLORATION

Abstract

The final frontier of space provides formidable hurdles to overcome, to achieve basic capacities, advanced applications, and future explorations, but also the opportunity to develop technologies and solutions that exponentially advance humanity across various fields and needs. In all of science and technology, nature presents the most efficient solutions to stringent problems as compared to artificial methods, thus making biology an impactful contender in the race to sustainable space exploration. This ranges from providing nutrition to astronauts and settlers, processing waste cyclically to minimize waste, and providing resources for future habitation otherwise needing numerous launches and fuel waste. Conversely, space research enhances living processes on Earth, such as faster cell and tissue growth by months, boosting biochemical efficiency by over 200%, and facilitating the development of novel features in existing organisms and their products otherwise impossible on Earth.

Although implementing biological techniques in space offers significant advantages for sustainable space exploration, it presents challenges in application development and future exploration. One concern is that microorganisms may behave differently in microgravity, with unknown consequences for biological experiments in space. Studies have shown that microbes can adapt to these conditions and become more virulent, potentially threatening astronauts and the spacecraft. The same issue applies to recombinant seeds and plants being tested and grown in space as potential food for astronauts. Many model organisms sent to space for study may, through possible mutations, emit micro- or nanoparticles, which could affect astronauts' respiratory, digestive, or nervous systems without immediate symptoms. Furthermore, while sending biological payloads into space, there are chances of possible spillage of mutant species, contaminating the Earth's upper atmosphere and thus acting as potential bioweapons in the long term.

Regulatory aspects of space biology are currently understudied. Issues such as ethics, liability, ownership of genetic material, transportation, weaponization, contamination risks, and security protocols are areas that require careful consideration. This paper briefly examines life science applications, explores their use in the extraterrestrial context, and highlights their respective benefits and challenges, particularly in terms of space sustainability. Subsequently, it delves into the legal dimensions relevant to their implementation in outer space missions. For this purpose, the paper reviews existing international and national legal frameworks applicable to life sciences in the context of off-planet operations. Conclusively, it considers legal challenges that arise in this context and deliberates on the ethical and responsible use of life science beyond the confines of Earth.