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宇宙に地球の生態系は必要か？

Do We Need a Terrestrial Ecosystem ?

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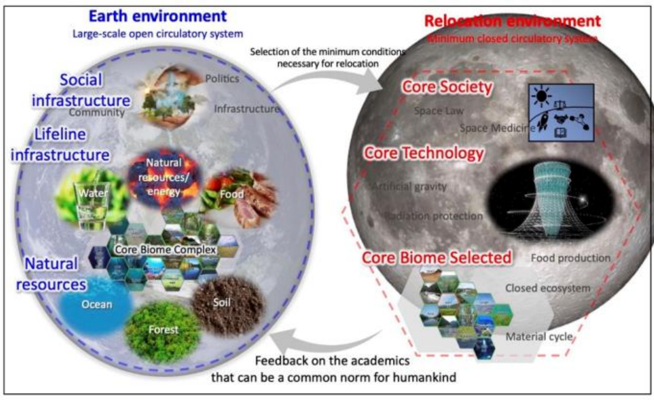
1. Three “Core” Concepts and Terrawindows

When planning planetary migration, it's essential to develop self-sufficient systems on other planets without relying on Earth for resources like food or construction materials. This system, known as the "core biome complex," includes both the life-support system and the global ecosystem. The necessary technology for maintaining life is termed "core technology." Together, these form the "core society," a self-sufficient system vital for establishing a "space society."

Figure 3 Terraforming vs terrawindows



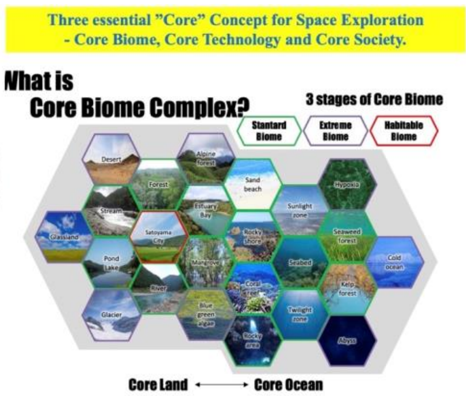
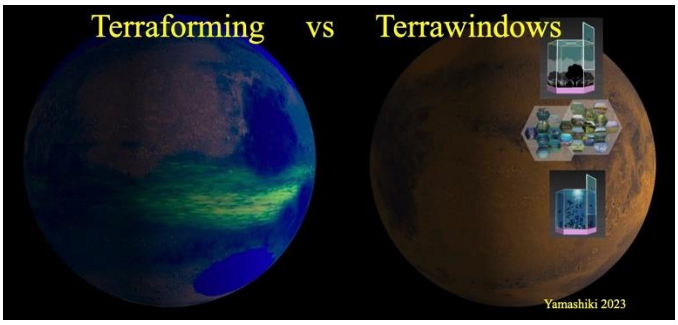


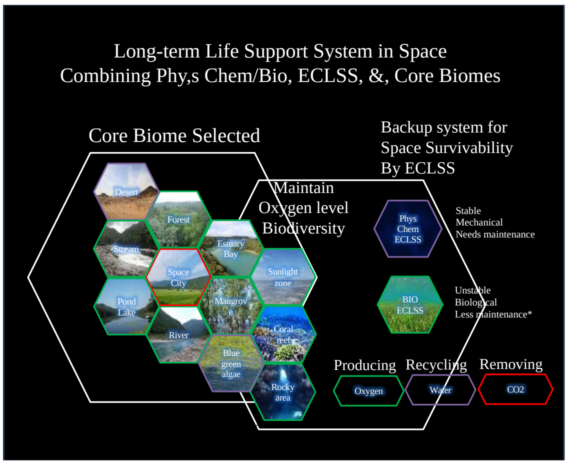
Figure 1: Three “Core” concept, Core Biome, Core Technology, and Core Society. Figure 2: Conceptual diagram of the core biome complex

The "core biome complex" simplifies the Earth's ecosystem by focusing on essential functions and is categorized into "Standard Biome," "Extreme Biome," and "Habitable Biome." To support human life in space, key



technologies include space radiation protection and artificial gravity, which are integral once life-supporting systems are established. Additionally, space law, sociology, and space medicine are crucial for sustaining relocated societies. Maintaining a space ecosystem raises challenges, such as controlling pests and managing pathogenic microorganisms. Introducing Earth's ecosystem to another planet is akin to an alien species invasion, raising concerns about Planetary Quarantine. Reproducing Earth's environment on a target planet may be best achieved through a completely enclosed dome structure, termed "Terrawindows," which is distinct from "Terraforming."

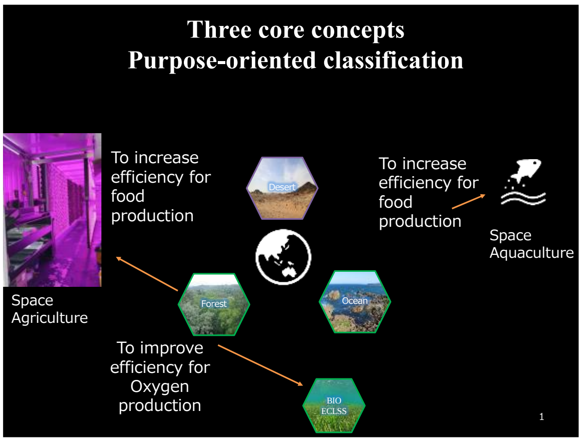
2. Natural capital classification & Life supporting classification



The idea of bringing an ecosystem into space was first realized in Biosphere 2, which was divided into modules like ocean, forest, savanna, and estuary, representing Earth's nature. This division is called "natural capital classification." In contrast, "life supporting classification" focuses on essential functions for human survival, such as food production and oxygen generation.

Space station construction and almost all current space manned mission systems are being designed based on "life supporting classification." However, for planetary migration, the "natural capital classification" will need consideration. At the same time, challenges with this approach include maintaining oxygen levels and necessary biomass, as untouched nature cannot sustain the current population in space due to the low efficiency of each compartment of a natural system. Therefore, integrating "life supporting classification" is crucial, and resolving this contradiction is key to constructing a core biome in space.

1.1 Natural Capital Classification



In the "natural capital classification," as seen in Biosphere 2, each ecosystem is classified similarly to Earth's. The Ocean, Forest, Savanna, and Estuary modules were hydrologically connected. However, maintaining this connection in Biosphere 2 altered the salinity of the Ocean module, highlighting the challenge of accurately replicating Earth's 70% ocean and 30% land ratio (ocean/rand ratio equals to 2.4). This imbalance and the scarcity of water make it difficult to maintain such a ratio in space – which makes it difficult to maintain and "artificial" hydrological system with correct salinity in a small ocean. As a compromise, Biosphere 2, where ocean/land ratio is just 0.2, focused on coastal ecosystems, but this led to the separation of land and ocean water cycles. The rainforest module, with its high biomass productivity, was separated from other modules to maintain temperature and humidity. Initially, 300 tree species coexisted, but now only around 100 species remain. Insects were introduced instead of animals due to their lower biomass consumption, but pollination has not been fully studied.

The ocean module was independent, featuring a wave-making device (artificial waves are essential for marine ecosystems), 7m water depth, and aeration. These features are crucial because water circulation doesn't occur naturally in the artificial ocean, necessitating constant energy input to maintain water quality and oxygen levels.

In these ecosystems, creating a mass balance is essential, particularly in modeling and monitoring the oxygen, carbon, nitrogen, and phosphorus cycles. This ensures the oxygen concentration necessary for the survival of aerobic organisms, including humans.

Even if we try to "bring in an ecosystem" or "simulate the Earth's ecosystem," engineering technology is still required to ensure human survival in a confined space. However, we should note that sometimes “engineering technologies” and “human favorable” nature does not fit for the “ideal” natural ecosystem where “biodiversity” become an essential parameter for its existence.

References

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