The biological rule that need to be followed to build the Martian, space station ecosystem

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September 19, 2023

Abstract

In this paper, the biological survival rule is described, based on which the cause of the failure of Biosphere 2 is analysed at the structural level to find solutions to the existing problems and guide biological practices in the future. The main cause of the failure of Biosphere 2 was that species were not introduced in classes, in order and in a step-by-step manner and not in sufficient time. A solution for establishing a biosphere involves step-wisely introducing species in the following order: prokaryotes, eukaryotes, plants, animals, and humans. The future Mars ecological engineering project should also adopt the above rule and follow the biological survival rule, starting from introducing prokaryotes and then simple eukaryotes to reproduce the process of biological evolution on Earth, which can also be applied to Lunar bases and space station.

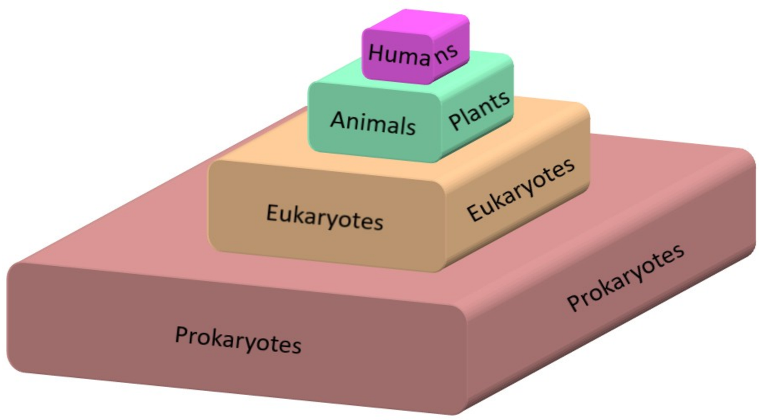
Keywords: Biological Evolution, Biosphere 2, Ecosystem, Mars, Rule, Space station, Species

In 2017, in his book *The End and Beginning of Mankind*, Zhengxi Wang proposed the "biological hierarchy law," which includes the "biological survival rule" and "biological evolution rule." The former is introduced below, with explained applications.

1.Biological survival rule

> Biological survival rule: When living in a closed biosphere, low-level organisms are indispensable for high-level organisms and the survival basis of high-level organisms, and the survival quality of low-level organisms affects that of high-level organisms. If there is a lack of low-level organisms leads to a nonsurvivable scenario for high-level organisms (Fig. 1).

Fig. 1



> Prokaryotes are the earliest living organisms on Earth and have survived for 3.8 billion years. They occupy the entire Earth, with extremely strong vitality. They are the basis for the survival and evolution of all living things and are the base of the biological hierarchy. On top of prokaryotes are eukaryotes (protists), on top of which are multi-cell organisms (animals and plants), which range from animals and plants with simple cells to vertebrate mammals at the highest level, there can be more levels in between. Humans are at the top of the biological hierarchy, which is, currently, reasonable (Wang 2017, pp 25-26).

The spatial and temporal collection of niches of species of various levels, in which the niches of low-level species cover those of high-level species while those of high-level species do not cover those of low-level species(Fig. 1).

The above biological survival rule is summarized based on the evolution and survival processes of organisms on Earth from prokaryotes to humans and is factual, with obvious correctness. It is the basic law of the ecosystem and very common but prone to being overlooked; "it seems unnecessary to summarize and formulate the rule, but I think it is very important and very necessary to summarize and formulate the rule because it will guide human's biological practice to always be on a right track." (Wang 2017, pp 26)

Prokaryotic bacteria and eukaryotic fungi can decompose the remains of plants and animals into water, carbon dioxide and organic matter, which in turn are absorbed and utilized by green plants to synthesize organic matter. Bacteria and fungi play important roles in the circulation of materials in the biosphere. Without them, the survival of high-level organisms is not sustainable.

Eukaryotes are an important part of biological evolution, i.e., cyanobacteria (prokaryote) → protozoa (eukaryote) → multi-cell organisms (plants and animals) → humans. Plants, animals and humans are eukaryotes; in the rule, eukaryotes refer to protists, fungi, etc., and algae can absorb carbon dioxide to release oxygen, improving the atmospheric environment while serving as the main food source of fish and shrimp. Plants and animals are main members of the biosphere, and at the top are humans, which require the support of animals and plants.

2. Reasons for the failure of Biosphere 2

Biosphere 2, a man-made 1.27 hectare closed ecosystem located in the desert of Arizona, USA, was built from 1987 to 1991. It contained seven biological communities, including approximately 3,000 species of animals and plants and approximately 1,000 species of microorganisms. The first closed mission started on September 26, 1991, and ended on September 26, 1993.

4 years after material closure of Biosphere 2, the trunks and branches became brittle and prone to collapses, and morning glories overgrew, becoming invasive. Among 25 vertebrate species, 19 went extinct (Burgess et al 1995). All pollinating insects died, making it impossible for plants to reproduce, and ants became dominant. The oxygen concentration in the closed atmosphere dropped from 21% to approximately 14%, not enough to maintain the life of the crew (Cohen et al. 1996); therefore, the crew was withdrawn, and the test failed.

Many papers have analysed the cause of the failure, but the root cause could not be found due to the lack of a theoretical basis, and an analysis could not be conducted at the macro level. The biological survival rule provides a theory that enables the identification of the problem and the development of solutions at the macro-structural level.

When completed, Biosphere 2 contained approximately 4,000 species, with a rather high biological diversity and quantity. So, why did it fail? A biosphere cannot be established by just assembling the needed species. Rather, it requires establishing and nurturing, which were absent in Biosphere 2, and the time spent on the ecological engineering project only lasted two years, during which all species were introduced almost simultaneously, without order. Essentially, this approach was not based on establishing and nurturing a biosphere but, rather, arranging flowers. When entering the biosphere, the crew members, eight in total, faced an unstable ecosystem because the low-level organisms (animals, plants, insects, and microorganisms) had survival quality issues, with a disrupted ecological equilibrium, affecting the survival of high-level organisms (human and vertebrates) and, ultimately, leading to the failure.

3. Methods for building the biosphere

Building a biosphere in a closed system requires compliance with the laws of the biological rule, species need to be introduced step-wise and sequentially, starting from bottom-level organisms. Bacteria and blue algae, which are at the bottom of the biological echelon, are most viable and thus must be introduced first, followed by the introduction of protozoa, fungi, algae, bryophytes, ferns, gymnosperms, angiosperms; animals introduced in the following order: invertebrates, fish, amphibians, reptiles, birds, mammals, and humans.

In terms of size (volume), small-sized species should be introduced first, followed by large-sized species, in the following order: microbes, low-height plants, insects, small animals, medium-height plants, medium-sized animals, high plants, large animals, and humans; in this way, the organisms have enough time to grow and adapt to the environment. For example, low-height plants should be introduced to an environment when there is good microbe survival, and insects and small animals should then be introduced to an environment when there is good survival of microbes and low-height plants; ultimately, humans can be introduced. Specifically, the order of the introduction can be fine-tuned, in accordance with the principle that species with a high ability to survive are introduced first.

During the introduction process, if diseased, extinct or overgrown species are observed or if ecosystem degradation or ecological disequilibrium occur, the introduction of species should be paused to determine the causes of the biosphere abnormalities; the problem should be solved biologically while the unfit species are excluded. After solving the problem and the ecological system equilibrates, the introduction of new species can be resumed.

Biological communities should be formulated reasonably according to the ecological niches of the species. The introduction of plants starts should start from the seeds so that they can grow in an adapted environment while changing the environment and being ecologically integrated. Insects and animals can usually reproduce and their offspring can survive well as long as domestic animals are first released into the wild. Species numbers should be introduced gradually, starting from small and short species, so that they can propagate and increase in number.

After microbes, plants and animals are well adapted and various indicators of the ecological system are normal and maintained for an extended time; the entry of crew members can then be considered. Crew members should not enter all at once, instead entering and exiting one-by-one, so that the threshold of the biosphere for the crew members can be determined.

Organisms at different stages require different living environments, so what are the standards? It is recommended that the environment parameters during the various stages of evolution of the Earth be used and that the oxygen content be equal to or higher than this standard.

4. Mars ecological engineering project

Mars colonization has always remained a hot topic (Boyle 2016), but researcher has raised objections, arguing that it will put humanity in danger (Wang 2020). Although there is no consensus regarding Mars colonization, other activities such as space travel and adventure and the non-reproductive inhabitation and work of adults who have completed physical growth and development can be considered, not to mention utilizing Mars as a spare base for the preservation of species from Earth, requiring Mars to be adaptive to organisms so it can serve as Earth's garden while providing an ecological environment in which humans can survive.

The key to the Mars ecological engineering project is water, and a large amount of water is needed. The plan is as follows: there is no liquid water on Mars but there is ice at the poles that can be utilized. Some researchers have proposed launching giant reflectors to reflect sunlight on the poles to increase the temperature so that the ice will melt.

With water on Mars, prokaryotic blue algae, which emerged the earliest on Earth, can grow and function (i.e., absorb carbon dioxide and release oxygen)（Friedmann et al. 1995; Baqué et al. 2016）, and subsequently, the multiplication of bacteria can weather rocks to form soil; then, simple eukaryotes can be introduced（Haynes et al. 1992; Huwe et al. 2019）… reproducing the process of biological evolution on Earth.

Mars is littered with rocks, and the soil has no nutrients for plant growth, making it impossible to feed animals. Soil formation and fertilization through the weathering of rocks by microorganisms takes a very long time; this process took more than 2 billion years on Earth. Large space station would require large amounts of soil, making it prohibitively expensive to rely on delivery by spaceship. With an increasing number of space station, the soil supply on Earth would become insufficien, we have to catch meteorites or mining asteroids in space, crush the stones and then add microbes to transform them into soil and used in space station. which is vastly different from Biosphere 2, in which, from the very beginning, fertile soil and rich marine resources were available.

5. Conclusion

Rome was not built in a day; creating a biosphere is like constructing a building, starting from the foundation and then up floor by floor, proceeding to the next process only after the previous process passes standards. The lesson from Biosphere 2 is that the biological survival rule must be followed and that a biosphere should be established with time and patience, in the right way and the right order (i.e., prokaryotes, eukaryotes, plants, animals, and humans), so that biological communities can achieve an ecological balance, with normal ecosystem indicators. The establishment of a biosphere is also a continuous process of trial and error, ultimately leading to success. With accumulated experience and the summarized procedures, it is possible to optimize the steps, thus leading to fewer mistakes while improving the success rate.

The establishment of a biosphere is actually a reduced version of the biological evolution of species on Earth (step-wise from prokaryotes to humans), and the difference lies in the introduction of species in a biosphere, which profoundly reduces the time span and the number of species through the partial replacement of natural selection by artificial selection (e.g., the introduction of species is an artificial selection process while the extinction of a species is a natural selection process). It would take at least 15 years to establish the ecosystem for Biosphere 2, and after that, a crew can be sent in batches. Mars ecological engineering projects would require even more time, the introduction of each species would take approximately 10 thousand years.

The steps of biological evolution are indispensable. This is the case on Earth, as should be the case for Biosphere 2, the Mars ecological engineering project, lunar bases, and space station. Before the birth of humanity, through evolution over 3.8 billion years (Mortilanno 2017; Ohtomo et al. 2014), rich and diverse organisms formed a prosperous and powerful biosphere, which has since changed the Earth's surface so significantly that it has made it entirely different from that of early Earth (Zhang 1998). Subsequently, humans came into being, and we are lucky that the ecosystem has provided powerful cornerstones for the survival and development of mankind. We must follow the biological survival rule to protect our green planet and future generations as well.

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