AFTER CHANDRAYAN-3 WHAT IS NEXT…… MICROBAYAN….????

Microbes on a Mission

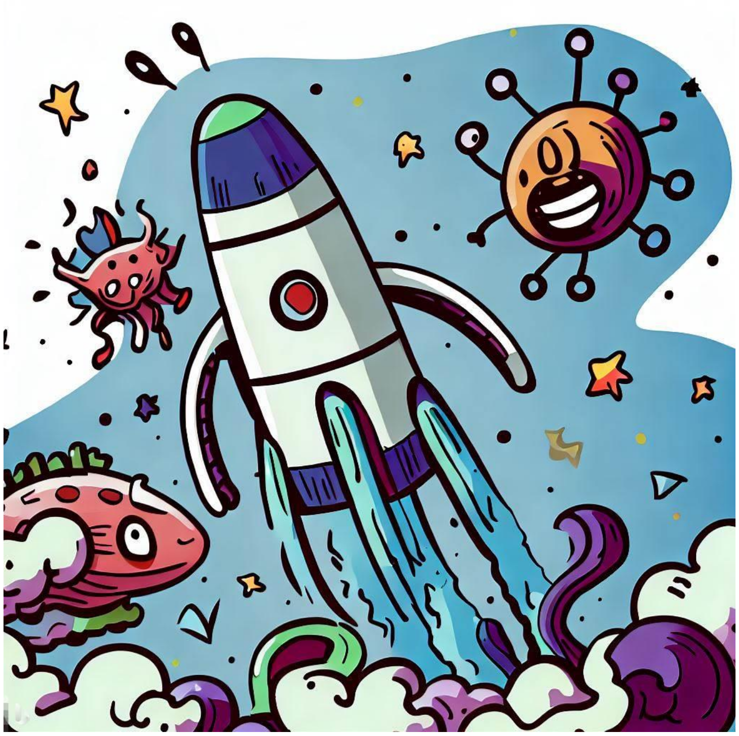
Shinto Selvam

Introduction

Chandrayaan-3 is a symbol of India's ongoing commitment to lunar and space research. As the mission progresses, it is anticipated to lead to new scientific breakthroughs, push the limits of space technology, and enhance India's standing as a major participant in the space exploration industry. Chandrayaan-3 has the ability to further information about the Moon's mysteries and its possible consequences for further human space travel, not just for the Indian scientific community.

We might learn more about the possibility of microbial life on the Moon as technology develops and our knowledge of the lunar environment expands. Our understanding of the Moon and its capacity to support any kind of life, even on a microscopic scale, will be greatly advanced by upcoming lunar missions, sample returns, and more thorough scientific examinations.

Any conceivable microbial life on the Moon, if it exists, would probably be considerably different from the life forms we are accustomed to on Earth due to the harsh and severe circumstances of the lunar surface



Lunar Exosphere

The fragile and imperceptibly thin layer of gases that envelops the Moon's surface is known as the lunar exosphere. The rich atmospheres seen on worlds like Earth are fundamentally different from this one. The exosphere is the outermost region of the Moon's "atmosphere," but the term "atmosphere" in this context is not totally appropriate due to the exosphere's low density and lack of a clearly defined border[1].

Lunar Exosphere Specifications

The majority of the gases in the lunar exosphere are either emitted from the Moon's surface by processes like outgassing or are sputtered off the surface by solar wind particles. Hydrogen (H2), helium (He), neon (Ne), argon (Ar), and trace quantities of other elements and compounds are among the prevalent gases found in the lunar exosphere.

Gas atoms in the Moon's exosphere are very thin and far from one another. The lunar exosphere has a significantly lower density of gas molecules per cubic centimetre than the finest laboratory vacuum found on Earth.

The Moon's exosphere lacks the gravitational attraction required to hold gases for a lengthy duration, in contrast to Earth's atmosphere. Any gas spilled onto the lunar surface has a high rate of space escape. Sputtering occurs as a result of the continuous bombardment of the lunar surface by solar wind particles, which cause gas molecules to be expelled into the exosphere. The exosphere is also enriched by gases produced during outgassing processes, such as those from the Moon's interior or previous volcanic activity.

Temperature can affect the lunar exosphere's composition and density. When the surface of the moon is exposed to strong sunlight throughout the lunar day, gas particles become more active and the exosphere grows. On the other hand, as a result of the lunar night's extreme temperature decrease, gas particles return to the lunar surface

Lunar dust's behaviour is also influenced by the exosphere's sparse atmosphere. Without atmosphere, the Moon's surface would be directly impacted by solar wind and micrometeoroids, leading to erosion and other unusual surface characteristics.

Microbes to moon

Sending microbes to the Moon provides a unique opportunity for scientific research and could offer valuable insights into the potential for life to survive and adapt in extreme environments beyond Earth

The major purpose of sending microbes to the Moon is generally scientific research, determining the viability of life in the harsh lunar environment, and researching possible consequences on both the Moon and the microorganisms themselves.

Microbe qualities that may be considered for a lunar mission

Extremophiles

Extremophiles are microbes that flourish in severe circumstances on Earth, such as high temperatures, extreme acidity or alkalinity, high salinity, or even in the absence of oxygen. Scientists may examine how these resilient creatures adapt and thrive in the harsh circumstances of the Moon by selecting extremophiles[2].

Radiation Resistance

Due to the lack of a protective atmosphere, the lunar surface is subjected to severe solar and cosmic radiation. Microbes with radiation resistance might shed light on how life on the Moon might deal with the increased radiation levels

Desiccation Tolerance:

The Moon's environment is exceedingly dry, with no liquid water on its surface. Microbes with desiccation tolerance, or the ability to survive severe dryness, would be studied to see how they cope with and recover from dehydration.

Survival in Low Temperatures:

Lunar nights may be bitterly cold, with temperatures plummeting dramatically. Microbes that can survive and stay metabolically active in low-temperature environments may be useful in comprehending cold-adapted life form

microorganisms with Low Nutrient Requirements:

Sending microorganisms with low nutrient requirements for growth and survival can assist examine how they use limited resources on the Moon, given that the lunar environment lacks considerable organic matter

Containment Measures:

Microbes chosen for lunar missions must be tightly confined to avoid contamination of the Moon's surface. Strains that have been well researched and have little potential to damage people, other living forms, or the lunar environment are often favoured.

Scientific aims:

The selection of microorganisms may be driven by the mission's unique scientific aims. Microorganisms that can aid in mining or processing minerals, for example, could be explored if the purpose is to study the possibility for in-situ resource utilisation (ISRU) on the Moon

Ethical problems:

There are ethical problems about transporting bacteria into space, including worries about planetary protection. To prevent contamination of the Moon with terrestrial microbes, careful risk evaluations and adherence to planetary protection standards are required

Extremophiles that might be considered for use on the Moon

Deinococcus radiodurans: called "Conan the Bacterium" due to its outstanding radiation resistance, Deinococcus radiodurans is a bacterium that has been called "Conan the Bacterium." It has the ability to endure high amounts of ionising radiation, making it a viable option for radiation shielding or as a bioindicator for measuring radiation levels on the Moon

Halobacteria: Halobacteria are salt-loving microorganisms that flourish in severely salty conditions such as salt flats or salt mines. These bacteria might be useful in lunar habitats with salt deposits or in investigations of desiccation resistance.

Chroococcidiopsis: This cyanobacterium is capable of photosynthesis and may live in parched environments such as severe dryness and intense radiation. It has been examined for its ability to perform oxygenic photosynthesis on Mars, and similar studies might be undertaken for lunar expeditions.

Acidithiobacillus ferrooxidans: This bacterium is noted for its capacity to oxidise iron and sulphur compounds and can flourish in very acidic settings. It might be evaluated for its function in mineral processing or resource extraction on the Moon.

Methanogens: Methanogenic archaea are microorganisms that create methane gas as part of their metabolism. On the Moon, they may be employed in bioreactors to create methane or other useful molecules for fuel or chemical synthesis

Thermophiles: Thermophilic bacteria flourish in high-temperature settings. Although the Moon's surface endures significant temperature changes, other places, such as the lunar subsurface, may have more stable and increased temperatures. Thermophiles may be useful for research in these areas.

Genetically engineered microbes:

Genetically modified microorganisms have tremendous potential for use on the Moon, particularly in the context of future lunar exploration and colonisation initiatives. While particular genetic changes would be determined by the mission objectives and the constraints offered by the lunar environment

The use of genetically engineered microbes on the Moon is still in the works, and it will take a collaborative effort from scientists, engineers, and policymakers to ensure the responsible and beneficial use of biotechnology in lunar exploration and future human habitation endeavours.

Present Scenario

ISRO (Indian Space Research Organisation), NASA (National Aeronautics and Space Administration), the Chinese Space Agency, and the Russian Space Agency are among the space research organisations around the world that have harnessed the power of microbial species to aid in their space exploration programmes. These minuscule creatures serve critical roles in understanding the impacts of space on biological systems, assisting long-duration space missions, and even opening the road for human colonisation of other celestial worlds

Bacillus subtilis.

Bacillus subtilis, a versatile bacterium found in soil and the human gastrointestinal tract, is one of the most widely researched microbial species in space exploration. Bacillus subtilis has been employed in various experiments onboard the International Space Station (ISS) by NASA and the European Space Agency (ESA). Its capacity to produce strong biofilms and withstand extreme space conditions, such as radiation and microgravity, makes it an attractive choice for researching the adaptation of life beyond Earth

Escherichia coli.

(E. coli) is another well-known microorganism that has been widely examined by ISRO and other international space organisations. E. coli is a bacterium that is often present in human intestines, but certain strains have been modified to create important proteins and medications. Because of its quick growth and genetic tractability, it is a vital tool for investigating the impact of space environments on biological processes and creating space biotechnology applications.

Saccharomyces cerevisiae.

Yeast, notably the Saccharomyces cerevisiae species, has been a significant component in numerous space experiments undertaken by NASA and the Russian Space Agency (Roscosmos). Saccharomyces cerevisiae is a single-celled fungus that is often used in brewing and baking. In space, it serves as a model organism for researching fundamental biological processes influenced by microgravity and space radiation, such as gene expression, DNA repair, and ageing

Arabidopsis thaliana:

Arabidopsis thaliana, a little flowering plant often known as thale cress, has been a useful resource for understanding plant biology in space. NASA and ISRO have done various studies using Arabidopsis to learn more about plant growth, development, and stress responses in microgravity. Understanding how plants adapt to space settings is critical for future long-term space missions as well as possible bioregenerative life support systems on other planets

⟸ Tardigrades (Water Bears):

Tardigrades are tiny, water-dwelling organisms that are renowned for their extraordinary tenacity. Due to their unusual appearance, they are sometimes referred to as water bears. They are resistant to harsh temperatures, intense radiation, and protracted desiccation. The Chinese Space Agency (CNSA) and other space agencies are interested in researching the possibility of life surviving interplanetary travel and hostile space conditions because of their extraordinary survival skills

Conclusion

Deploying bacteria on the Moon is critical for lunar research and possibly future human occupation for scientific, technical, and practical reasons. While the Moon's surface is unfriendly to most living forms, bacteria, particularly genetically modified extremophiles, might fulfil numerous critical functions.

It is critical to stress that microorganism deployment on the Moon must be done carefully, with rigorous risk evaluations and respect to planetary protection protocols. It is critical to keep the lunar environment free of terrestrial microbes in order to preserve its scientific integrity and the possibility of identifying native lunar life.