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The Evolutionary History of Montastraea: A Brief Insight into the Ancestral Origins of Montastraea

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Abstract: This research paper provides insights into the ancestral origins of Montastraea. The fossil record and microscopic skeletal analysis proves the Rugose corals are linked to Montastraea and also gives an insight into how they evolved. Montastraea cavernosa has had a long evolutionary history, from having the early Rugose corals as their ancestors to being a very resistant species to our pollution of oceans.

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I. INTRODUCTION

Montastraea is a genus of colonial stony coral of the Faviidae family, found in the Caribbean seas. It is native to the Limón basin of Costa Rica and the Bocas del Toro basin of Panama (1). It is the only genus in the monotypic family Montastraeidae and contains a single species, Montastraea, which is known as great star coral. It forms into massive boulders and sometimes develops into plates whose polyps are the size of a human thumb. They extend completely at night (2), (3), (4). The fossil records show a deep insight into its ancestral origins. Montastraea currently does symbiosis with zooxanthellae, a type of algae that can live with symbiotic relationships (5). 50% of Montastraea annularis has been lost in the seas of Southwest Puerto Rico (6).

- *Hypothesis:*

Montastraea started as Rugose corals in the Ordovician and did not start evolving in the Late Cretaceous. They developed star-like corallite structures after the Permian extinction, and after the Cretaceous extinction, they reappeared in the Miocene era, 24 MYA, looking like the modern-day Montastraea cavernosa.

II. THE THEORY

A. Earliest Ancestors:

According to the fossil record, the history of Montastraea traces back to the (7) Ordovician Period, which began 485.4 million years ago, following the Cambrian Period, and ended 443.8 million years ago. The first Rugose (Rugosa) corals trace back to this period.

Fig 1: Rugose Corals of the Devonian

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Fig 2: Rugose Coral of the Author's Private Collection

This is a comparison between Devonian Rugose corals and an Ordovician Rugose coral of the author's private collection (M.001- Ordovician). Notice the structural similarities. (1 corallite- 0.5cm)(Figure A- Rugose corals of the Devonian, Figure B- Rugose Coral of the author's private collection)

B. Shrinking and Extinction

As time passed and the Permian era began, the Rugose coral populations plummeted rapidly. The Rugose corals shrank rapidly to cope with the environment. As the Permian ended 251.902 MYA (8), the Rugose corals faced extinction.

Fig 3: A Late Permian Fossil Image

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➢ *Rugose Coral Structure Decreasing*

This is a remnant of a shrinking Rugose coral (IMP.003/M.002- L.Permian) of the author's private collection (Figure C- A Late Permian fossil image)

C. Post-Permian Evolution

As the Triassic started about 248 MYA, Montastraea slowly started developing new structures. Instead of the circular center and straight septa, Montastraea developed individual coral skeletons and a wall. The septa grew bigger and the polyps were moderately sized. The circular center shrunk. Through the Mesozoic era, the Montastraea colonies shrunk to compete with other coral species. This went on through the Jurassic (206 MYA) and the Cretaceous (142 MYA)

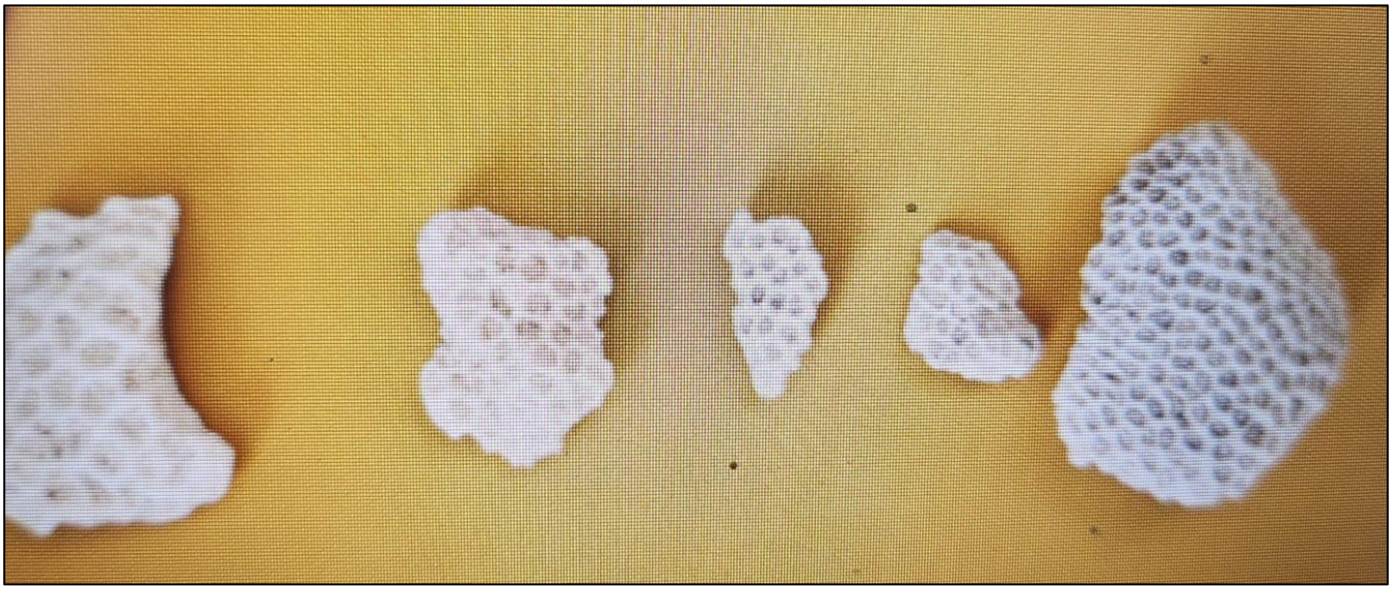

Fig 4: The Fossils of the new Montastraea across the Mesozoic

This is an image representing the adaptations of the new Scleractinia Montastraea. Notice the shrinking structure and the increasing colony size (M.003, M.004, M.005, M.006, M.007-Triassic, Jurassic, and Cretaceous) (Figure D- The fossils of the new Montastraea across the Mesozoic)

D. Post-Extinction Recovery

After the great extinction which occurred 66 million years ago, which was caused by the Deccan Traps, and the Chicxulub meteorite impact, Montastraea did not appear till the Miocene (24 MYA).Every individual corallite had a small center and septa as big as an ant's leg. These colonies lived in hundreds, if not thousands. These were the modern Montastraea cavernosa colonies, leading to what we have today.

Fig 5: A Fossil of Miocene Era Montastraea Cavernosa

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This is an image of Miocene-era (24 MYA) Montastraea. Notice how the coral structure of each individual coral has shrunk rapidly (M.008-Miocene) (1 corallite- 0.25cm). Each corallite had almost microscopic centers and small septa no bigger than an ant's leg. (Figure E- A fossil of Miocene era Montastraea cavernosa)

III. METHODS

Many methods were used to prove this theory right. The fossils were observed with a magnifying glass and a microscope. The structures were also compared to separate them out from Septastraea, a type of coral from the same family, Faviidae.

IV. RESULTS

Microscopic examinations of the skeleton of M.001 and a modern-day Montastraea fossil have revealed that the structures of Rugose Montastraea and modern-day Montastraea match, specifically the septa. According to detailed observation, as no test can be run on fossil, the skeletal systems have differed through their evolutionary stages. The Rugose corals had large and broad skeletons, the Scleractinian Montastraea(Mesozoic) had straight and curved skeletons, often twinned. The Miocene era Montastraea had shorter skeletons, but the same structures (9).

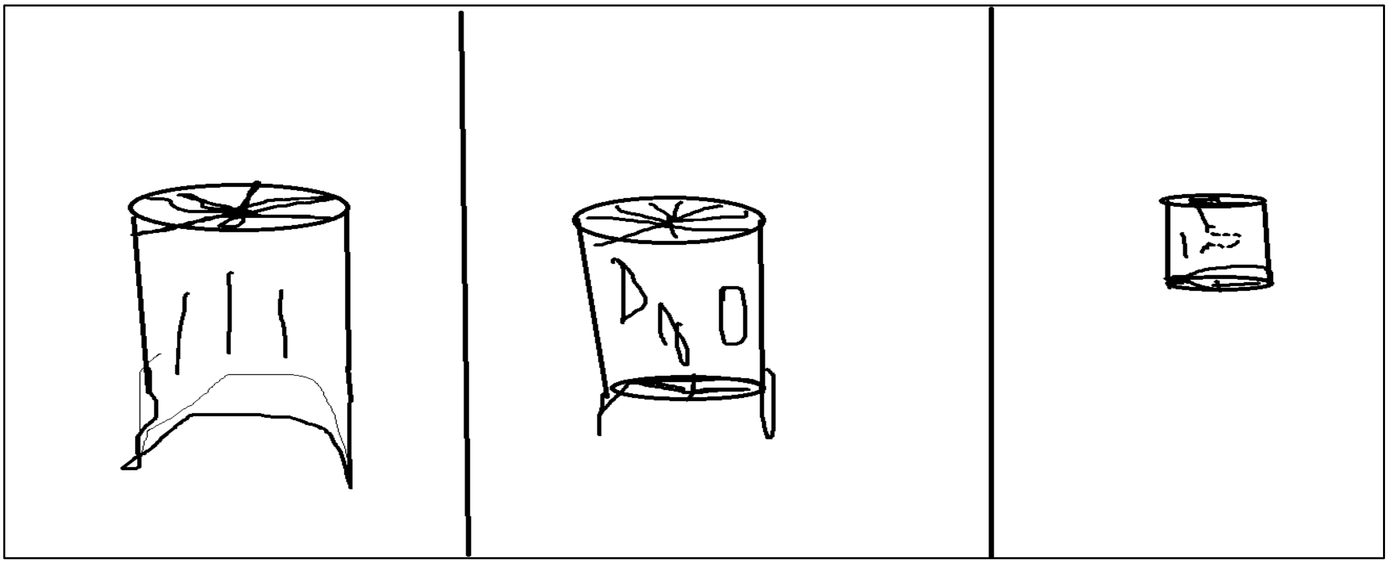

Fig 6: Drawing of Montastraea Skeletons

A drawing comparing the skeletons of Montastraea through its evolutionary stages. The Rugose corals had broader , slanted skeletons, which then evolved into a straight skeleton with an inward curve at the end, which further evolved into a smaller, shorter structure.....(Figure F- Drawing of Montastraea skeletons).

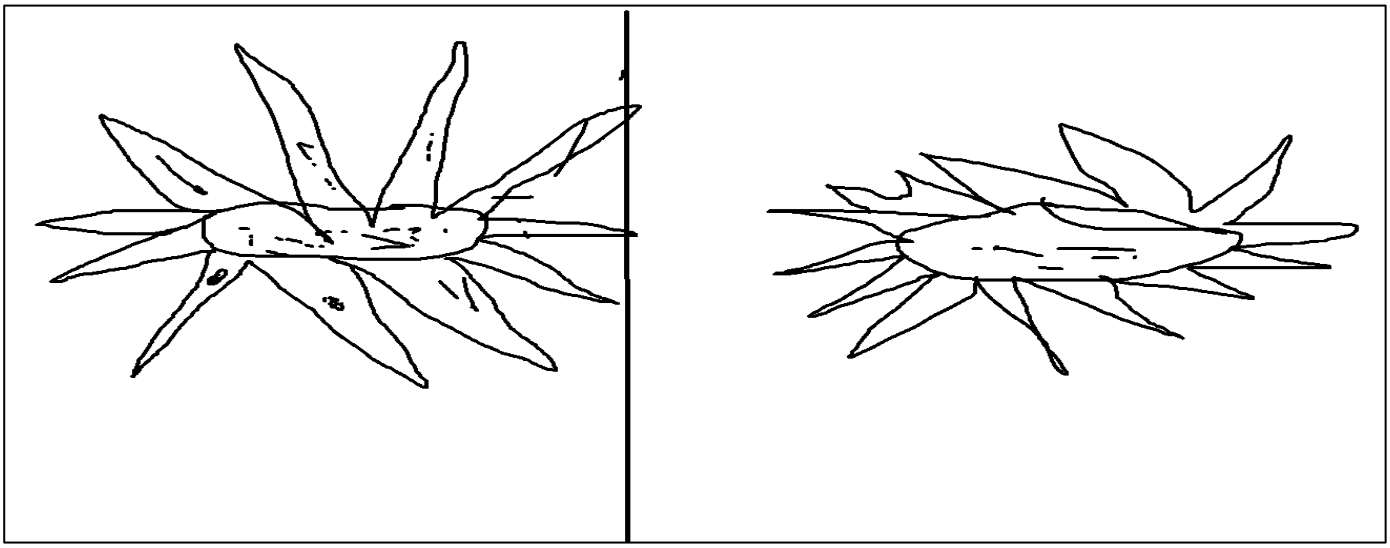

Fig 7: Septa of Montastraea Cavernosa under a Microscope- Representation

This drawing represents the microscopic analysis findings of similarities in coral structure, specifically septa (Figure G- Septa of Montastraea cavernosa under a microscope- representation).

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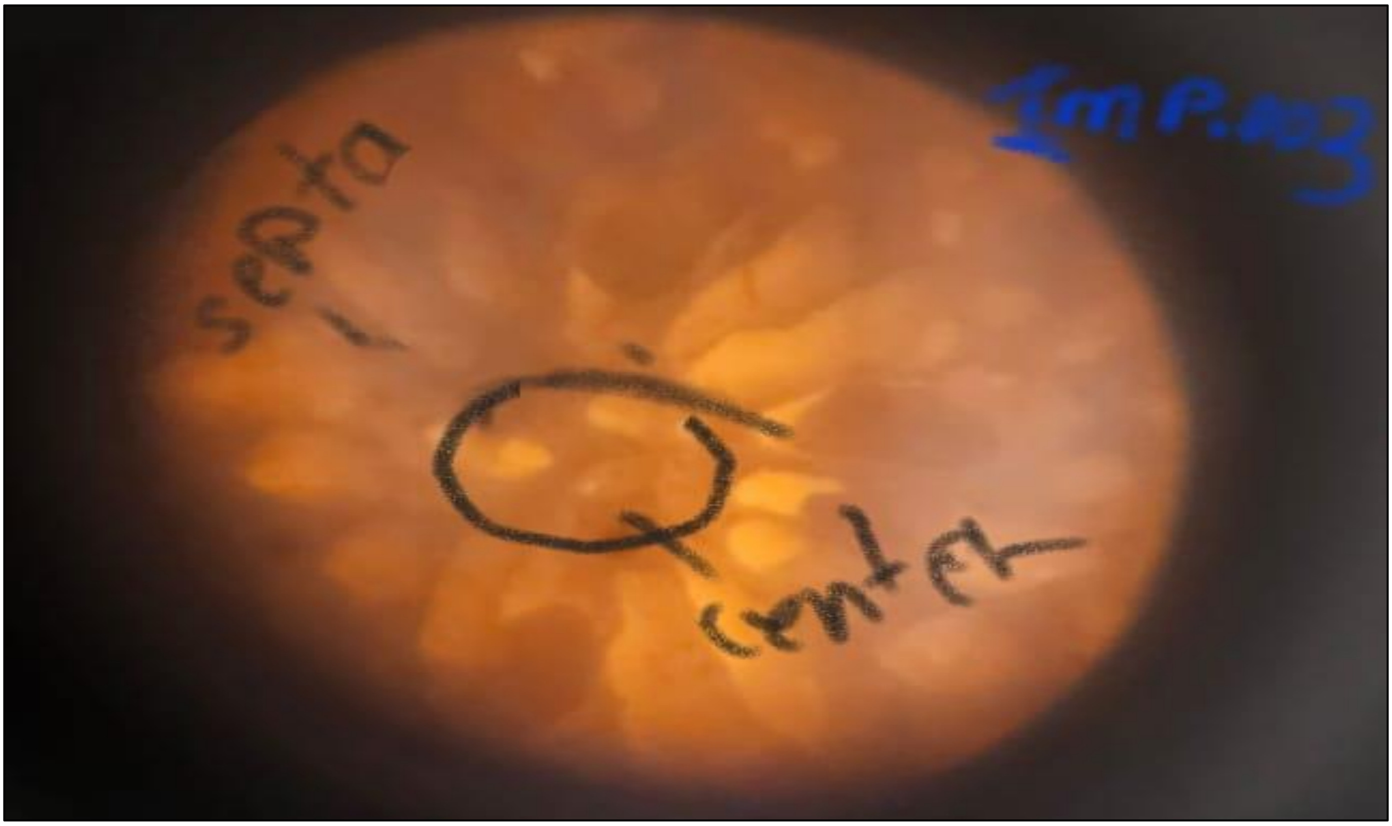

Fig 8: Microscopic Analysis of IMP.003- Permian

Image representing the structure of IMP.003/M.003- L.Permian under a microscope (Figure H- Microscopic analysis of IMP.003- L.Permian)

Fig 9: Montastraea Fossil - Scleractinia- Mesozoic) Observed under the Microscope.

A Scleractinian Montastraea (Figure I- Montastraea fossil - Scleractinia- Mesozoic) observed under the microscope.

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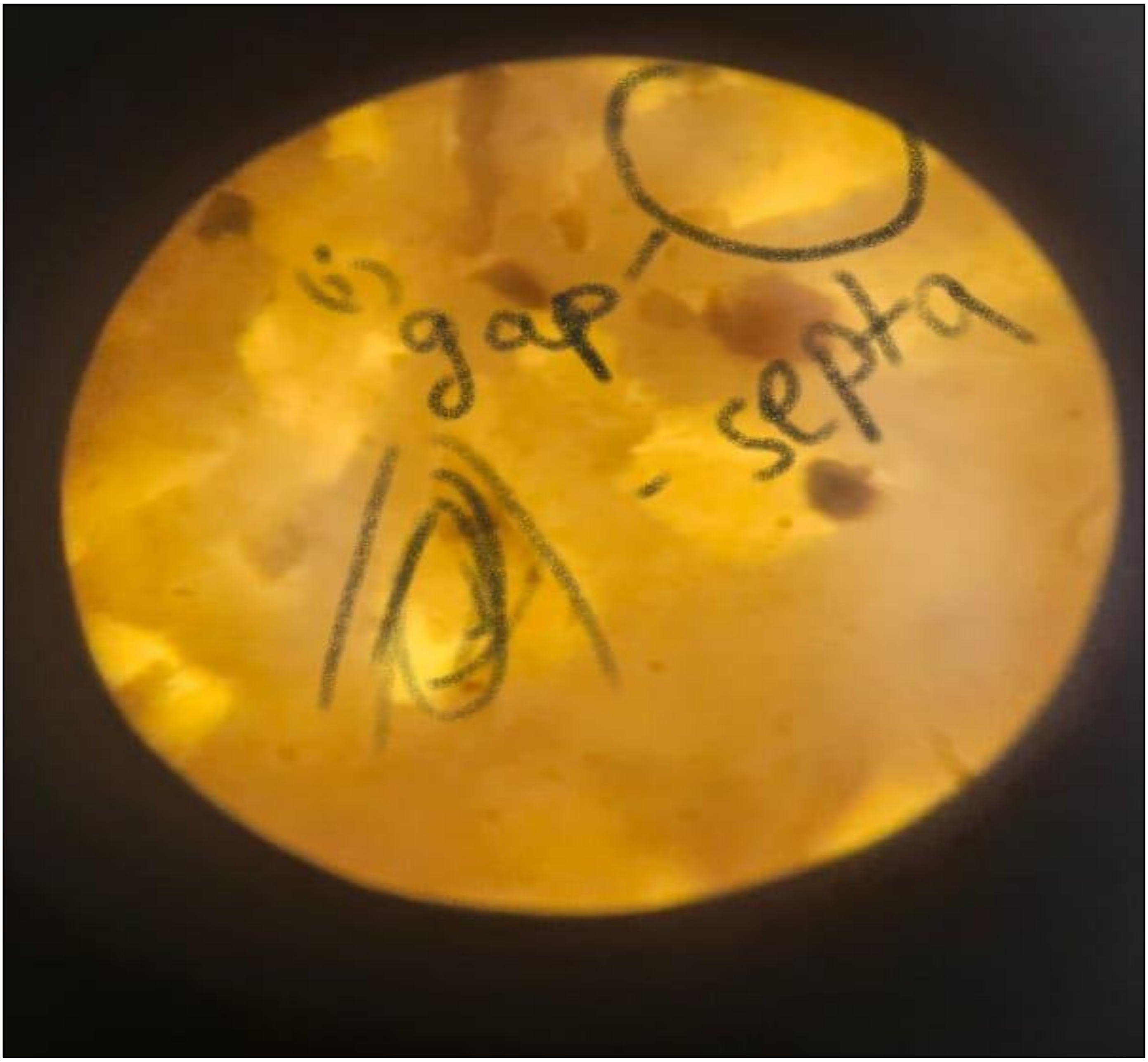

Fig 10: Miocene Montastraea Fossil under the Microscope

A modern Montastraea cavernosa (Miocene) observed under the microscope (Figure J- Miocene Montastraea fossil under the microscope)

In these three images, the gap and the septa structures match, in this case, a flower-like pattern. This proves the theory right as a Rugose coral's structure matches the structure of this Jurassic era Scleractinian Montastraea cavernosa and a modern Miocene era Montastraea cavernosa.

V. DISCUSSION

Many tests can be commenced to prove this theory right. For example, a microscope can be lended and used to observe the septa, the corallite structure and the skeleton of individual Montastraea cavernosa. A magnifying glass can also be used and the number of septa also matters. Montastraea has a rounded colony and corallite shape, which separates out from Septastraea.

VI. CONCLUSION

Understanding the evolutionary history of Montastraea cavernosa can show a brief and vast origin into the species' evolutionary history- from rugose corals to what we have today- the modern Miocene era Montastraea Cavernosa.

VII. SUMMARY

- Montastraea corals originated in the Ordovician period.
- They experienced significant population decline and shrinking during the Permian, followed by a Triassic revival with structural changes.

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- After another extinction event, modern Montastraea emerged, characterized by smaller individual coral structures.
- These variations in coral skeletal structures across different evolutionary stages support this theory.

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AUTHOR'S INFORMATION

Darsh Jignesh Sagala is a 7th-grade student at Indian School Al Ghubra, Oman, with a strong interest in paleontology and astrophysics. He actively pursues independent research on evolutionary biology and astronomy, with a particular focus on fossils, coral evolution, and celestial observation. Outside the classroom, he regularly uses his telescope and microscope to deepen his understanding of the natural world. This paper represents his first formal contribution to scientific literature and reflects his ongoing commitment to exploring the intersections of earth and space sciences.

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➢ *Links (Additional Ones Included)*

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