

The Use of Microbialite and Fossil Samples to Introduce Astrobiology to K-12th Grade Students While Aligning with the Next Generation Science Standards

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Introduction: A challenge in K–12 science education has been incorporating topics that do not obviously align with the science standards into classroom activities. One such topic is astrobiology. Fortunately, astrobiology is an interdisciplinary field with various disciplines that can fit into the Next Generation Science Standards (NGSS). In this abstract, we showcase an activity that uses various NGSS in Life and Earth Science to introduce astrobiology to a rural K–12th-grade school system.

Location: The Taylor Observatory-Norton Planetarium is a program run by the Lake County Office of Education to support science education throughout Lake County, California, through field trips to a centralized STEAM Center and in-classroom outreach. Lake County is a rural, isolated county with over 72% of students qualifying for the free and reduced-price meals program, and around 57% are minority students.

Goals and Learning Objectives:

- Apply the Scientific Method.
- Identify both what is life and the diversity of life within Earth's history.
- Identify patterns in rock layers to support an explanation for changes in a landscape over time.
- Learn about missions such as the Perseverance Rover that use similar techniques to look for evidence of past microbial life on Mars.
- Introduce students to the interdisciplinary aspect that makes up astrobiology.

These learning objectives revolved around the NGSS standards 3-LS4 and 4-ESS1-1. 3-LS4 deals with the evolution and diversity of life and includes such topics as biodiversity in the fossil record and how changes in environments may encourage natural selection or extinctions. Meanwhile, 4-ESS1-1 deals with the application of stratigraphy to determine the age of rocks and changes in environments and includes topics such as biostratigraphy and the law of superposition. These two standards serve as the basis for two major disciplines of astrobiology: biology and geology. These NGSS standards are built upon later middle school and high school NGSS standards.

Learning Activity: The activity incorporates fossils, rock samples, and roleplay to introduce 4th and 5th-grade students to basic concepts of geology and paleontology and their application in astrobiology.

Fossils: This activity uses invertebrate and microbialites fossils collected (with permission) from different sites. We selected each invertebrate fossil to showcase the diversity of life throughout Earth's history while including a mixture of obscure and easily

recognizable species for K-12th-grade students. We added microbialites fossils to the mix that contain prominent features so students can easily visualize them. The fossils are unprocessed, allowing students to develop their own interpretations.

Rock Samples: We created ideal rock sequences that show changes in the environment, by collecting various sedimentary rocks with different grain sizes and distinct sedimentary structures. The rock sequence complements the fossils by showcasing evidence of the type of habitat the organisms thrived in and how this environment no longer exists in the modern day at the location.

Roleplay: Our activity is built around a group of 15 students and takes around one hour to complete. The activity can include larger groups of students with modifications.

We use roleplaying by having students imagine being scientists tasked with interpreting rock samples collected from a sample return mission to three different planets. The different planets include Mars-like, Europa-like, and Titan-like planets. With a modern context of each planet, students are split into groups and allowed to explore each group of rock samples and create their own interpretations of which rocks contain evidence of life, how the organism might have looked like, and what environment the organisms lived in. As students explore each planet, educators will facilitate learning objectives. Students will switch stations every ten minutes.

At the end of the activity, students learn what environment each group of samples represents and what each fossil is. Afterward, students learn how geologists use similar observations to reconstruct conditions on Earth billions of years ago when life first evolved and how astrobiologists use these same techniques to search for similar environments that could have supported microbial life billions of years ago on Mars. This activity is simplified for K-3rd-grade students or expanded for middle and high school students.

Summary: Our application of basic concepts of geology and paleontology allows us to bring astrobiology research that the Perseverance rover and other space missions are conducting within the grasp of understanding of K-12th grade students engagingly and interactively.

References:

NGSS Lead States (2013) *The National Academies Press*

Domagal-Goldman, S. et al. (2016) *Astrobiology*, 16, 561-65