

Design Your Own Deep-Sea Vent Experiment

Grade Levels: 7-9

Time: 1 week

Number of Students: Entire Class

Seating Arrangement: Groups of 4-6 students

Objective:

Through this activity, students will learn to conduct research in a team setting and apply their knowledge to the design of a scientific experiment. Through the process, they will accomplish the following objectives:

- Develop inquiry and research skills
- Work collaboratively and refine communication and cooperation skills
- Gain knowledge on current research of hydrothermal vents
- Learn to think through a problem from both a scientific and engineering perspective

Materials:

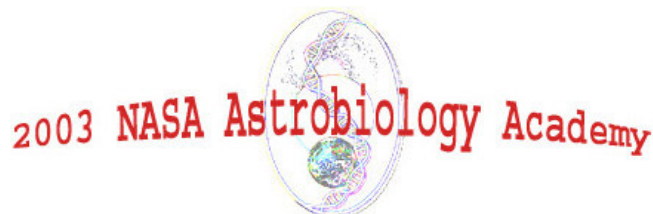
Poster board and art supplies for student presentations

Research packet

Background Information:

Deep-sea vents host a variety of extremophilic microbial life including thermophilic (heat loving) and chemoautotrophic (extracting energy from chemicals) bacteria and archaea. These microbes are considered to be the earliest forms of life on Earth. Extremophilic microbes may thrive in a wide range of conditions within the solar system, expanding the 'Habitable Zone'. Microbes similar to those found around hydrothermal vents may be found in liquid water oceans beneath the ice of Europa or subsurface hydrothermal systems on Mars. Future solar system exploration will have strict sterilization requirements to insure that probes do not contaminate other worlds. Sterilization requirements are critical for identifying new life on other planets instead of stowaway microbes.

Deep-sea vents offer scientists a unique environment in which to study life; they serve as an analog for studying life found elsewhere in the universe. They are unique because high temperatures are found in such close proximity to low temperatures, there are extremely high pressures, there is a unique chemical environment, and there is an absence of light.



The hydrothermal vent environment provides a relevant backdrop for astrobiological studies. The geology, ecology, and biochemistry of the vent site offer insights into the three fundamental questions of astrobiology:

1. How does life begin and evolve?
2. Does life exist elsewhere in the universe?
3. What is the future of life on Earth and beyond?

Exploration of the vents is important to astrobiology because:

- The deep-sea vents are an extraterrestrial analog.
- The vents serve as an early Earth analog.
- Knowledge of extremophiles leads to a better understanding of the evolution of life.
- Extremophiles may be found elsewhere in the universe.
- We can practice using self-contained experiments in remote environments.

The conditions at the Snake Pit hydrothermal vent site are steady:

Longitude = 23° 23' N
Latitude = 44° 56.1' W
Depth = 3480 meters
Temperature = 335-356°C
pH = 3.7-3.9
Oxidizing conditions

Motivation:

A world-famous director is making an IMAX film about astrobiology and extreme life and is organizing an expedition to the deep-sea vents. Who wants to be in the movie?

Activity Procedure:

Scenario: You have one week to research hydrothermal vents and come up with an astrobiology-related experiment to carry down on a deep sea submersible to the Snake Pit dive site in the Atlantic Ocean. The length of stay at the dive site will be 1-4 days. You then must come up with goals and a timeline for your project, which will theoretically take place on a 10-week time frame. Use background research to design the experiment. At the end of the week, you will present your experimental design and organizational plans to the rest of the class.



Students will need to:

- Come up with a timeline
- Designate teams and leaders (organizational structure)
- Design an experiment with procedures and protocols
- Develop a list of goals
- Explain the reasoning behind and the importance of the experiment (what questions are you answering?)
- Make plans for when the experiment gets back
- Prepare a poster presentation for the class

At the end of student presentations, the NAABA2K3 (NASA Ames Astrobiology Academy 2003) Project and Results can be presented.

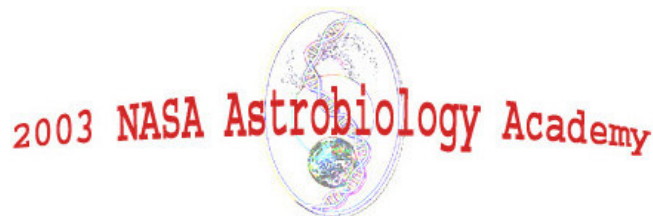
Elaboration:

The NASA Ames Astrobiology Academy was given the same scenario that you just completed. This is what they chose for their project: Microbiologically Influenced Corrosion at Deep-Sea Vents.

Within a week, the 13 Academy students designed a study of the potentially small difference in corrosion rates that may occur due to microbes that live and metabolize at depth around deep-sea vents. The experiment included shuttle tile and metal samples that, when exposed to the extreme conditions and microbial communities near a vent, produced corrosion and biofilms. The corrosion and residues on the various materials were measured and compared. By comparing corrosion rates, the researchers looked for deviations from predicted corrosion and experienced corrosion, which suggested biological activity.

An apparatus comprised of the material samples was engineered, assembled, and sent to a deep-sea hydrothermal vent aboard the Russian MIR deep-sea submersible. The sample holder was a metal rod covered with a non-conducting Teflon tube. Metal samples and Teflon sample-holders were placed on the rod and separated by non-conducting ceramic spacers. Large steel endplates prevented samples from touching the sea floor and allowed Russian technicians to place a stainless steel t-bar that the robotic arm could accept during retrieval. The apparatus spent over 24 hours on the ocean floor in the Snake Pit area (along the Mid-Atlantic Ridge) accumulating biological material and corroding. After a retrieval dive, the apparatus was returned to the surface and preserved for analysis at Ames Research Center.

Analysis methods included: 1) a scanning electron microscope (SEM) to identify basic chemical composition of surface and to produce high magnification images of microbial morphology. 2) Staining which allowed for preliminary identification of microbe metabolism and the presence of DNA. 3) Surface approximation of corrosion to measure the extent of corrosion as a percent of area using image analysis software.



The metals were ordered into a hierarchy of expected corrosion. Once the experiment returned, the Academy students measured the amount of surface area corrosion and compared their results with theory. Any metal displaying greater relative corrosion than predicted strengthened the case for biologically induced corrosion.

The goals of the project were to:

- Gain a better understanding of microbiologically influenced corrosion
- Contribute to the science of hydrothermal vents as early Earth and extraterrestrial analogs
- Learn about planning and cooperation necessary for undertaking science research in a group dynamics
- Work towards obtaining publishable results

The project drew on the diverse talents of all thirteen Academy students and the resources of the Academy infrastructure. The first phase of the project included researching and discussing various project topics. Project proposals were prepared by each individual and considered over the course of a week. The experiment outlined above was selected by group consensus. One week was available for research on project feasibility, potential analysis methods, materials acquisition, materials processing, assembly, sterilization, and shipping. Assembly procedures and protocols included in the experiment package were written during the final stages of apparatus preparation. Long-term plans were simultaneously developed including construction and paper draft due dates, analysis deadlines, and general coordination plans.

Evaluation:

Encourage students to participate in a question and answer session after each presentation so that the class can collectively choose one or two prime candidates for the deep-sea vent experiment. The class may decide on the criteria for evaluating experimental designs (feasibility, cost, ease of assembly, relevance to astrobiology, etc.).

Resources:

Preparation of a research packet for the class, containing 3-5 articles with a bibliographic list for further research, is recommended.

Background on Astrobiology:

<http://astrobiology.arc.nasa.gov/roadmap/index.html>

Background on the NASA Ames Astrobiology Academy Group Project

<http://academy.arc.nasa.gov/2003/mica.htm>



Background on hydrothermal vents:

<http://www.divediscover.who.edu/infomods/vents/>

<http://www.ocean.udel.edu/deepsea/level-2/geology/vents.html>

<http://www.ocean.washington.edu/people/grads/scottv/exploraquarium/vent/intro.htm>

<http://www.pmel.noaa.gov/vents/home.html>

Activity Developed by the NASA Ames Astrobiology Academy, Summer 2003, Moffett Field, CA

Contact

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