Galapagos Rift Expedition

Who Promised You a Rose Garden?

Focus

Biological communities associated with hydrothermal vents along the Galapagos Rift
Mapping

Grade Level

7-8, 9 (Biology)

Focus Questions

What types of animals do you find along the Galapagos Rift and where?

Why are there no "roses" growing in the Rose Garden along the Galapagos Rift?

Learning Objectives

Students will conduct independent research to discover what types of organisms can survive near hydrothermal vents.

Students will learn how organisms living along hydrothermal vents can survive in the absence of sunlight and photosynthesis.

Students will use mapping skills to learn more about the Rose Garden at the Galapagos Rift.

Additional Information for Teachers of Deaf Students

The vocabulary words are integral to the unit but will be very difficult to introduce prior to the activity. They are really the material of the lesson. There are no formal signs in American Sign Language for any of these words and many are difficult to lip-read. If some of this information has not already been covered in your class you may need to add an additional class period to teach vocabulary and teach some of the background information to the students prior to the activity. Having the vocabulary list on the board as a reference during the lesson will be extremely helpful.

Materials

- ❒ One map showing where spreading ridges are located
- ❒ National Geographic Video entitled "Dive to the Edge of Creation," if available
- ❒ Pictures of hydrothermal vents from website http://www.divediscover.whoi.edu
- ❒ Pictures of animals that live near hydrothermal vents from website http://www.divediscvoer.whoi.edu
- ❒ One Student Research Sheet per student
- ❒ One map of the Rose Garden per student
- ❒ One Student Inquiry Sheet per student

Audio/Visual Materials

Internet connection for student use

Teaching Time

Two periods of 45 minutes each

Seating Arrangement

Individually or in groups of four

Maximum Number of Students

35 students

Key Words

Hydrothermal vent
Galapagos Rift

Ocean ridges
Ocean plates
Chemosynthetic
Photosynthetic
Symbiosis
Plume
Distribution
Hydrothermal fluid
Dissolved
Molten
pH
Oases
Chemo-autotrophic
Chemosynthesis
Photosynthesis
Symbiotic
Colonize

Background Information

Deep hydrothermal vents were first found by scientists using cameras, sonar, and CTD back in 1976 along the coast of the Galapagos Islands. One year later, scientists traveled over 2,900 meters below the surface of the ocean using the manned submersible, Alvin, for the first *in situ* human observations of these newly-found structures on the deep sea floor. Scientists were very surprised and excited to find plumes of aqua-colored shinnering water rising from the seafloor. Scientists had just discovered the first hydrothermal vent.

Near vents, water travels down through cracks in the seafloor and is heated by hot, molten rock far below the ocean crust. Temperatures can reach as high as 400°C. As the water heats up, it reacts with the rocks in the ocean crust. These chemical reactions remove all of the oxygen from the water and, therefore, the water becomes acidic. The hot water rises to the surface of the seafloor and spews out of the vent openings. The pH of this fluid varies from roughly 3 to 5 and temperatures, at their most extreme, can reach over 350°C. This hydrothermal fluid carries with it dissolved metals and other chemicals, like hydrogen sulfide, from deep beneath the ocean floor.

You might think that such a harsh environment would be devoid of life, yet the areas around hydrothermal vents are small "oases" among the sparsely-populated habitats of the deep sea. The productivity of a hydrothermal vent area rivals that of salt marshes and shallow-water coral reef habitats. Scientists who discovered the first vent system back in 1977 were quite surprised to see this area teeming with a variety of different life forms. The secret was held in the chemo-autotrophic bacteria able to harvest energy from the chemical fluid emitted from the vents! These bacteria use sulfide to create food. This process is called chemosynthesis.

Using the process of chemosynthesis, a variety of bacteria thrive on sulfide and are able to synthesize sugars from these chemicals. These bacteria provide the base of the food chain for hydrothermal vent communities. Since no light is available to organisms living along vent systems, photosynthesis cannot occur. The bacteria are also thermophyllic, or heat loving. Some of the bacteria can survive temperatures over 100 degrees Celsius! Many animals living in vent communities harbor symbiotic, sulfide-loving bacteria within their bodies; the bacteria synthesize sugars from sulfide and provide sugar to their host while the host provides a safe refuge for the bacteria.

Since the discovery of hydrothermal vents, scientists have given interesting names to the thriving communities of tubeworms found in this extreme environment. These names include "Rose Garden," "Garden of Eden," and "East of Eden." This activity includes research on the part of your students and the use of a map of the Rose Garden generated by Dr. Robert R. Hessler from Scripps Institution of Oceanography at the University of California in San Diego. This map was generated in 1985 as Dr. Hessler and a team of scientists revisited the Rose Garden at the Galapagos Rift and collected data on the distribution and abundance of animals in this vent area. Their goal was to compare their observations in 1985 to what was observed during an earlier study of the area in 1979. Scientists used a towed camera system and collected over 2,000 photographs to generate a complete picture of the vent field.

The first objective of the activity is to involve students in independent research as they learn more about the bizarre animals that make up the thriving vent communities in the region. The second objective is to get students to use their mapping skills to describe some of the discoveries Dr. Hessler and his team of scientists learned in 1985 as they explored the Rose Garden.

The "Rose Garden" vent site at the Galapagos Rift was so named in 1979 because of its thickets of tubeworms, which looked like long-stemmed red roses. (Photo by Kathleen Crane, WHOI) from www.divediscover.whoi.edu

Below you will find background information on several of the organisms found in the Rose Garden at the Galapagos Rift.

Giant tubeworms can reach lengths of over six feet. They have a bright red plume filled with blood at the end of a long white tube. This bright red plume functions as a gill and takes up sulfur, oxygen, and carbon dioxide. The giant worms can retreat into their tubes if disturbed or threatened and adult tubeworms lack mouths, stomachs, and anuses. They have an odd-looking organ that fills most of the tube and is filled with sulfide-loving bacteria. When opened by scientist, this organ stinks!

Tubeworms provide sulfide to the bacteria and in return, the bacteria produce sugars from sulfide for the tubeworms. This is an example of symbiosis. Giant tubeworms seem to thrive in areas where the flow from the vent is rapid. When the flow from a vent slows or stops, the giant tubeworms begin to die and are replaced or eaten by other organisms. Tubeworms are among the first animals to colonize a hydrothermal vent area. In 1979, when scientists first visited the Rose Garden along the Galapagos Rift, tubeworms were everywhere. When they returned to the site in 1985, the tubeworms were very scarce; this difference is likely due to changes in the vent flow.

Mussels are often the first shellfish to begin living at a hydrothermal vent site. The mussels clump together in cracks in the seafloor and contain bacteria in their large, fleshy gills that can produce sugars from sulfide. The bacteria provide sugars to the mussel. The mussel provides refuge to the bacteria. This is an example of symbiosis. Mussels can also filter food from the water, so if hydrothermal fluid stops flowing, mussels can survive for a short period of time.

The mussels have a foot that creates a strong thread that the mussel uses to attach itself to something on the seafloor. The mussel can shoot out the thread and then reel its body along the length of the thread, so movement is possible. Being able to move might be an advantage that mussels have over tubeworms; if a vent stops flowing, mussels can move to a new location with higher vent flow. Crabs and shrimp eat mussels. In 1979 and 1985, mussels were very abundant at the Rose Garden on the Galapagos Rift. In 1985, the mussel population seemed larger throughout the vent area.

Clams colonize hydrothermal vents after mussels. Each clam has a big muscular foot that it wedges into cracks in the ocean floor. A clam also uses its foot to move around. Like the mussels, clams depend on the symbiotic bacteria that live in their gills. These bacteria use the chemicals in the hydrothermal fluid to produce sugars. The clams use some of these sugars for food. Crabs and octopi eat clams. In 1979, clams were not present in the Rose Garden in large numbers. By 1985, there was a notable increase in the clam population at the Rose Garden.

Anemones are related to jellyfish and corals. They prey on other animals using stinging cells, called nematocysts, located on their tentacles. At the Rose Garden, anemones were abundant in 1979 and in 1985. Anemones were typically found farther away from the vent openings than the tubeworms, mussels, and clams. Anemones, however, were found closer to vent openings than the serpulid worms.

Serpulid worms build curly-cue tubes made out of calcium carbonate. These worms are sometimes referred to as "feather duster" worms because they have a feeding plume that looks like a feather duster when it is extended out of the top of the tube. They form dense beds at the edges of vent fields. Compared to the tubeworms, mussels, clams, and anemones, the serpulid worms are found furthest from vent openings at the Rose Garden.

Bacteria (from www.divediscover.whoi.edu) - are microbes found at hydrothermal vents. These microbes form the base of the food chain in hydrothermal vent areas. They are chemo-autotrophic, capturing energy from chemicals flowing out of a vent. They then use the energy to create sugars from carbon dioxide. Bacteria grow everywhere! Some bacteria live inside clams, tubeworms, and mussels, forming symbiotic relationships with these animals.
Each species of bacteria prefers a specific water temperature. Different species extract energy from different chemicals, including hydrogen, hydrogen sulfide, and iron. Scientists have barely begun to learn about these microbes found in the deep sea. They are using genetic techniques to identify new species and are trying to learn where they live and which vent chemicals they use.

These are just a few of the organisms that can be found living near hydrothermal vents. Your students will be able to find many more! These may include the squat lobsters, shrimp, octopus, dandelions (a siphonophore related to the jellyfish), and Zoarcid fish. The websites and magazine articles listed in the Resources Section will provide valuable information as your students begin to conduct their research.

Depending on the level of your class, you may wish to incorporate the dynamic nature of vent systems into your discussions. During the life of a vent system, there are many factors that can alter the flow out of the vent. As faulting occurs at the spreading centers, the shape and the distribution of the flow can be altered, as some areas may begin to produce flow for the first time, while others areas may stop flowing altogether. Some flow channels may even become clogged over time. Changes in flow pattern may result in the creation of new vent openings and the extinction of others. Animals, like the giant tubeworms that thrive where there is high vent flow, may suffer when vent flow is suddenly reduced. Other animals, like mussels and clams, can rely on vent flow to support the bacteria living in their bodies, but can also filter feed in the absence of vent flow. So as your students ponder over the 1985 map of the Rose Garden, tell them that tubeworms were very abundant in 1979. Ask them why they think there were fewer tubeworms in 1985.

Learning Procedure

1. Introduce your students to the physical characteristics of hydrothermal vents. Use pictures and maps to supplement your introduction.
2. Ask them what kinds of animals, if any, could live in such a harsh environment. Record student responses.
3. Get students to devise a food web that involves humans. Point out that the food web, like all terrestrial food webs, is dependent on plants and their ability to produce sugars through the process of photosynthesis.
4. Review the process of photosynthesis, if necessary.
5. Ask students if they think photosynthesis can occur near hydrothermal vents. Record student responses.
6. Provide students with as many resources as possible.

7. Have students research three or more organisms that live along hydrothermal vents and ask them to record their findings, including adaptations for survival, on their Student Research Sheet.
8. Provide one week for students to conduct independent research.
9. The following week, begin a discussion about the biology of hydrothermal vents by asking students to share their favorite hydrothermal vent organism with the rest of the class. Have as many pictures of hydrothermal vent organisms as possible available for students to observe.
10. Discuss the adaptations of each organism presented to the class and include a discussion of chemosynthesis, if a student does not address this at some point during the class.
11. Hand out a map of the Rose Garden to each group of students and explain what the map represents and how the data were collected.
12. Provide an Inquiry Sheet to each student. If your students work more effectively in groups, then divide the class into teams of four, and ask each team to fill out one Inquiry Sheet.
13. Provide 30 minutes for your students to complete the Inquiry Sheet.
14. After 30 minutes, discuss each answer to each question on the Inquiry Sheet with the class.

The BRIDGE Connection

www.vims.edu/BRIDGE

Choose Ecology from the sidebar and go to the Deep Sea Link. There are numerous links to sites about hydrothermal vents located here.

The "Me" Connection

Ask students to consider whether or not humans could ever harness and utilize the energy produced at hydrothermal vents.

Connections to Other Subjects

Biology, English/Language Arts

Evaluation

Have students write a "Home Wanted" ad for two hydrothermal vent organisms. The ad should include a picture of the ideal home and a full description of those items the organism would need to find in its new home.

Extensions

Have your students visit http://oceanexplorer@noaa.gov and www.divediscover.whoi.edu with a member of their family each day to keep up to date with the latest Galapagos Rift Expedition discoveries.

Have students create a 3-D model of a hydrothermal vent area.

Resources

http://oceanexplorer@noaa.gov and www.divediscover.whoi.edu - Follow the Galapagos Rift Expedition daily as documentaries and discoveries are posted each day for your classroom use. A wealth of resource information can also be found at both of these sites.

http://www.divediscover.whoi.edu
http://www.nationalgeographic.com
http://www.marine.whoi.edu/ships/alvin/alvin.htm
http://www.ocean.udel.edu/deepsea
http://www.life.bio.sunysb.edu/marinebio/hotvent.html
http://amnh.org/nationalcenter/expeditions/blacksmokers
http://www.pbs.org/wgbh/nova/abyss/life/extremes.html
http://www.ocean.washington.edu/people/grads/scottv/exploraquarium/vent/intro.html
http://www.pmel.noaa.gov/vents/home.html
http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/oceanography_recently_revealed1.html
http://www.whoi.edu/WHOI/VideoGallery/vent.html/

Articles from past issues of *National Geographic*
Oases of Life in the Cold Abyss, October, 1977
Return to the Oases of the Deep, November, 1979
Light in the Abyss Reveals Life, November, 1994
Rebirth of a Deep-sea Vent, November, 1994
Life at the Bottom, May, 1998

Deep-sea Geysers of the Atlantic, October, 1992
Deep Sea Vents: Science at the Extreme, October, 2000

Gordon, David George. "Explosions from the Deep." *National Geographic World,* June 2000, 18-21.

Haymon, Rachel and R. A. Lutz. "Rebirth of a Deep-Sea Vent." *National Geographic*, November 1994, 114-126.

Hessler, Robert R. et. al. 1988. "Temporal change in megafauna at the Rose Garden hydrothermal vent." *Deep-Sea Research*, Vol. 35(10-11): 1681-1709.

Rona, Peter A. "Deep-Sea Geysers of the Atlantic." *National Geographic*, October 1992, 105-109.

Van Dover, Cindy Lee. 1996. *"The Octopus's Garden: Hydrothermal Vents and Other Mysteries of the Deep Sea."* Perseus Press.

Van Dover, Cindy Lee. 2000. *"The Ecology of Deep-Sea Hydrothermal Vents."* Princeton University Press.

Woodman, Nancy. 1999. *"Sea-Fari Deep."* National Geographic Books.

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard C: Life Science

- Structure and function in living systems
- Populations and ecosystems

Content Standard D: Earth and Space Science

- Structure of the Earth system

For More Information

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http://oceanexplorer.noaa.gov

Selected by Science Educators from NSTA

Student Handout

Student Research Sheet

Hydrothermal Vent Organisms

Name: ______________________________

Name of Organism: ______________________________

Drawing of Organism:

Description of Organism, including Adaptations for Survival: ______________________________

Student Handout

Student Inquiry Sheet

Name:

1. What types of organisms did Dr. Hessler find at coordinates C,8?

2. What types of organisms are most abundant on the northern-most edge of the vent field?

3. Which organisms are most abundant on the southern edge of the vent field?

4. Of the animals listed on the key, which do you think were least abundant at the Rose Garden in 1985?

5. Which two animals are found in similar locations?

6. If you were a hungry octopus looking for mussel to eat, what is one set of coordinates where you could be sure to find a yummy meal?

7. How many meters across, from north to south, is the largest clump of tubeworms?

8. Why do you think the tubeworms can only be found in two small pockets along the hydrothermal vent?

9. Why would scientists create a map like the one of the Rose Garden in 1985?

Student Handout

Map of the Rose Garden