Regional Class Research Vessel

Oregon State University

The Axial Seamount: Life on a Vent

Timeframe
50 minutes

Target Audience
Grades 5th- 8th

Suggested Materials
- Hydrothermal vent organism cards
- Poster paper
- Marking pens
- Sticky notes
- Painter's tape (to show connections)

Contact:
SMILE Program
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Description

This activity asks students to understand, and build a food web to describe the interdependent relationships of hydrothermal vent organisms. Hydrothermal vents were only discovered in 1977, and as more vents are explored we are finding out more about the unique creatures that live there. In Life on a Vent students will learn about vent organisms, their feeding relationships, and use that information to construct a food web.

Objectives

Students will:
- Make a food web diagram of the hydrothermal vent community
- Show the flow of energy and materials in a vent ecosystem
- Learn about organisms that live in extreme environments and use chemosynthesis to produce energy
- Make claims and arguments about each organisms place in the food web

Essential Questions

What do producers and consumers use as energy at hydrothermal vent ecosystems, and how does that energy travel through the trophic levels of the ecosystem?

Background Information

Hydrothermal Vents, How do They Form?
Under sea volcanoes at spreading ridges and convergent plate boundaries produce underwater geysers, known as hydrothermal vents. They form as seawater seeps deep into the ocean's crust. As the seawater seeps deeper into the Earth, it interacts with latent heat from nearby magma chambers, which are possibly fueling a nearby volcano. Once the freezing cold water heats up deep near the crust, it begins to rise. As the extremely hot seawater rises, it melts the rocks it passes by leaching chemicals and metals from them through high heat chemical reactions. Eventually, this hot gaseous mixture will make its way to the surface of the seafloor and form a hydrothermal vent. When these vents form they look like chimney

stacks bellowing out white or black smoke, which depends on the composition of the rock the seawater interacted with. The compounds that were leached from the rock and the continual seeping and heating of seawater, provide the nutrients to sustain life on the vent.

However not many organisms can survive in such an extreme and volatile habitat, yet the ones that do are known as "extremophiles." **Extremophiles** have the ability to thrive in extreme environments (e.g. under high pressure and temperature), and they show that life is possible in the harshest environments.

Hydrothermal Vents at Axial Seamount
Axial Seamount is an underwater volcano located 300 miles off the Oregon coast. It is the most active submarine volcano in the NE Pacific. An underwater volcano is VERY hot (reaching up to 700 degrees C) and it is very deep! 4,626 feet below sea level and rises 3,609 ft high. Axial Seamount is part of a string of volcanoes that straddle the Juan de Fuca Ridge, a tectonic-plate boundary where the seafloor is spreading apart. Researchers have been monitoring the seamount for the past 15 years by measuring tiny movements in the seafloor. Erupted most recently in 2015, 2011, and 1998. Video: http://axial20103.blogspot.com/2013/08/where-is-axial-seamount.html

How can we go there to explore hydrothermal vents found at Axial? Now, we go to the seafloor virtually! A remotely operated vehicle (ROV) is deployed off a research vessel and shows live video of the seafloor. The manipulator arms take samples and deploys and recovers instruments or sensors. We find all kinds of organisms living around Axial Seamount. However, prior to ROVs, we had to go there physically. Currently, Oregon State University is developing three new Regional Class Research Vessels to further the legacy of sea exploration. They will all be able to deploy ROVs to explore hydrothermal vent ecosystems.

The first hydrothermal vents were discovered in 1977 on an oceanic spreading ridge near the Galapagos Islands. This team used the Alvin (Figure 1), a tiny submarine that took teams of engineers and scientists to the seafloor. Hydrothermal vents were surprising to find, but that large numbers of animals around the vents was an even greater surprise. This is because conditions near the vents are "extreme" when compared to places that we normally think of as being suitable for living species. Water emerging from hydrothermal vents may be as hot as 400°C, is highly acidic, and usually contains large amounts of hydrogen sulfide which is highly toxic to many animals. Moreover, these vents occur more than a mile beneath the ocean surface, far too deep for photosynthesis which was assumed to be essential to all major biological communities. The fact that hydrothermal vents are home to thriving communities of previously unknown animals suggests that we should not be too quick to use our own needs as a basis for judging whether conditions are "acceptable"

Next Generation Science Standards

PERFORMANCE EXPECTATIONS:
5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

DISCIPLINARY CORE IDEAS:
LS2.A.: Interdependent Relationships in Ecosystems
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

SCIENCE AND ENGINEERING PRACTICES:
Developing and Using Models

CROSSCUTTING CONCEPTS:
Systems and Systems Models
Energy and Matter

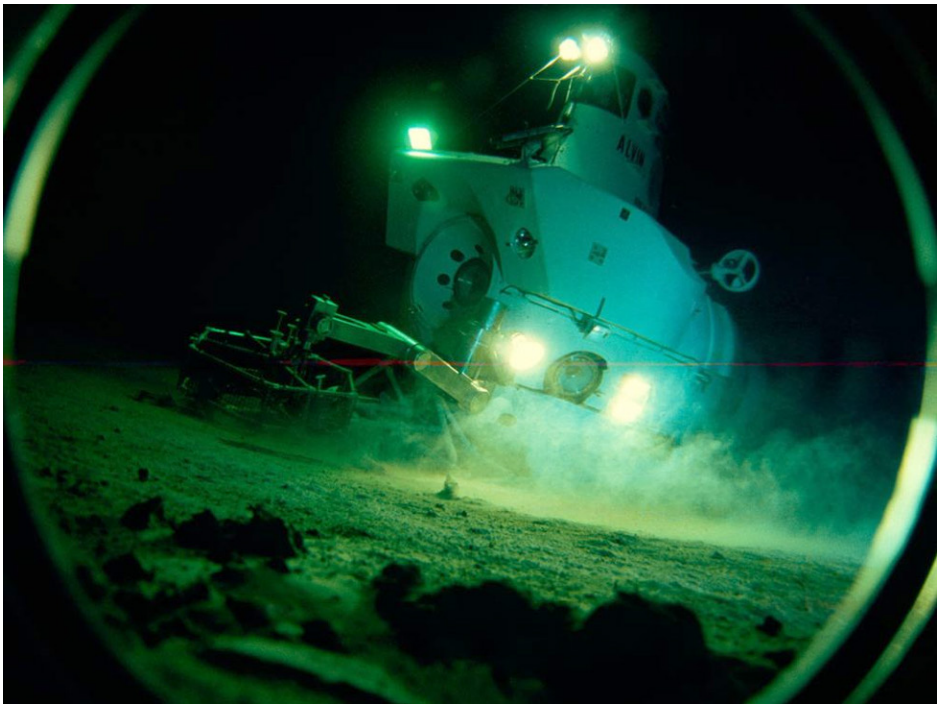


Figure 1: The Alvin

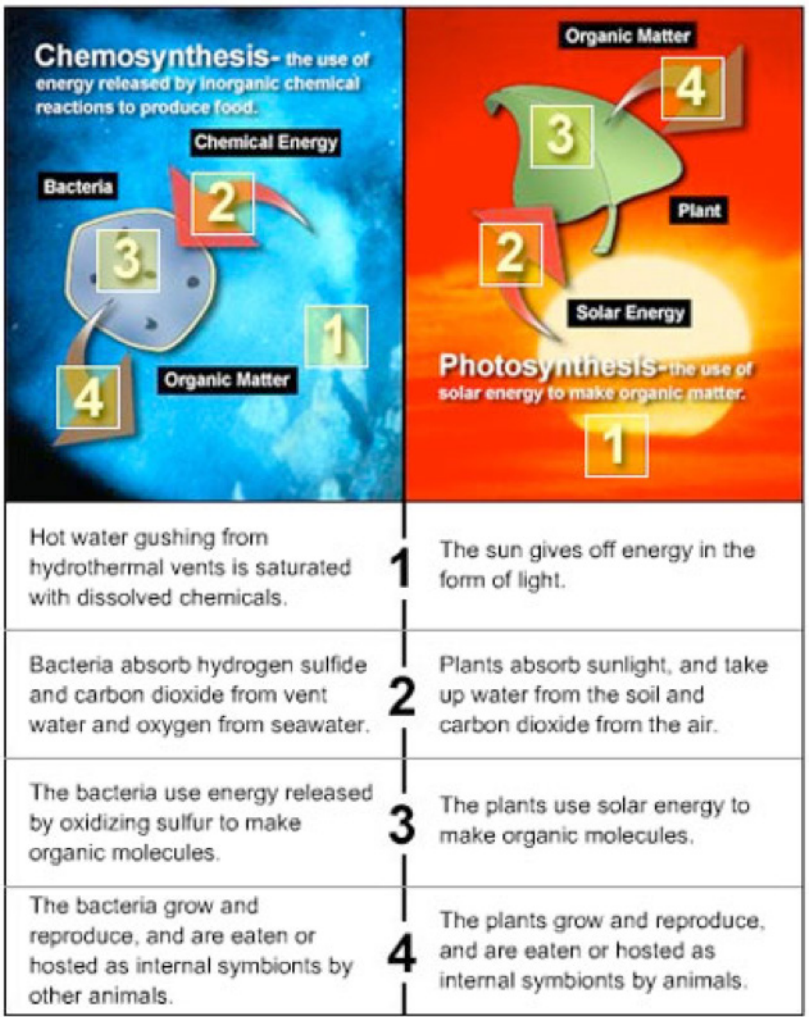
or "extreme" for all other forms of life.

Chemosynthetic Bacterium and Food Webs

Lava flows and hydrothermal vents provide habitats for a diverse assemblage of organisms in the volcano's summit caldera, while a thick layer of pelagic mud offers a far different habitat for biological communities at Axial's base. Organisms that live around hydrothermal vents don't rely on photosynthesis to turn water and carbon dioxide into sugar and oxygen. Instead, bacteria and archaea use a process called chemosynthesis. **Chemosynthesis** is the use of energy released by inorganic chemical reactions to produce food, but, unlike plants, each species uses different pathways to produce food.

These chemosynthetic bacterium are the base of the vent community food web, and support hundreds of species of animals. All of these animals may become food for predators such as polychete worms, crabs, fishes, and octopi. Some of these predators may spend most of their time outside the vent community, and visit only briefly to find food. Most species found in vent communities, though, are not found anywhere else. Many new species of animals have been found as more hydrothermal vents are explored.

There are three major categories of living organisms in an ecosystem, and each has a special role. Together, **producers** (plants that produce energy from sunlight or bacteria using chemosynthesis), **consumers** (animals, both herbivorous and carnivorous), and **decomposers** (and detritus



Hot water gushing from hydrothermal vents is saturated with dissolved chemicals.	1	The sun gives off energy in the form of light.
Bacteria absorb hydrogen sulfide and carbon dioxide from vent water and oxygen from seawater.	2	Plants absorb sunlight, and take up water from the soil and carbon dioxide from the air.
The bacteria use energy released by oxidizing sulfur to make organic molecules.	3	The plants use solar energy to make organic molecules.
The bacteria grow and reproduce, and are eaten or hosted as internal symbionts by other animals.	4	The plants grow and reproduce, and are eaten or hosted as internal symbionts by animals.

feeders) are the building blocks of a food web. Food energy produced by producers is cycled through the ecosystem through food chains and more complex food webs by way of a series of energy/feeding levels called trophic levels. **Primary Producers**, chemosynthetic bacterium, make up the first trophic level, or base of the pyramid. **Primary Consumers**, herbivores, rely on producers for food energy and make up the second trophic level. **First Order Carnivores** make up the third trophic level, and are predated upon by **Top Carnivores**. There are similar trophic levels to any food web, even when compared to life at deep sea vents, yet there is one major change — the food webs at hydrothermal vents do not rely on sunlight but rather, chemosynthesis.

Activity Introduction

1. Introduce students to hydrothermal vents and the organisms that live there by watching the following video: https://oceantoday.noaa.gov/lifeonavent/
    a. Ask students to write down what they see, think, and wonder.
    b. Can use another video listed in the Resource section.
    c. Ask the students how they think these animals survive without any sunlight?

i. No photosynthesis

2. Talk to students about animals in a food chain (producers, consumers, and decomposers), and the role of photosynthesis in ecosystems on land.
   a. Example
      1. Plains/Forest: Soil Organism - Grass - Deer - Wolf
      2. Grassland: Soil Organism - Worm - Bird - Hawk/Snake
      3. Q: What role does sunlight play in these food chains?
      4. Q: What role do decomposers play in these food chains?

3. Ask students if they'd expect similar relationships between an energy source (sun), minerals/chemicals (soil), decomposers (bacteria, fungi, invertebrates) and organisms (producers and consumers) found on land at a hydrothermal vent?

4. Tell the students they are going to explore a hydrothermal vent ecosystem, and sort their creatures in to decomposers (feed on detritus - dead and decaying matter that is taken up by other organisms), producers (make things that other organisms consume), primary consumers (feed directly on primary producers), carnivores (feeds on primary consumers and/or other carnivores), top carnivores (feeds on primary consumers, in order to track the energy traveling through the ecosystem).

5. Give students a set of "Vague" organism cards. Read the cards. Have each group discuss and predict what types of feeding paths may exist among the animals described. Determine the "initial" positions of each card in their food web model. (can tape to wall/whiteboard/floor, and use painters tape or expo markers to mark feeding relationships between organisms).
   a. Each set of cards can be broken down to just a few cards in a group.
   b. If down have the students combine cards later to make a whole class model.
   c. Each chart group must have: *Simple Chemicals (e.g. CO_2, O_2, CH_4, H_2S) - Primary Producers (first trophic level) - Primary Consumers (second trophic level) - First Order Carnivores (third trophic level) - Top Order (fourth trophic level)* shown on their chart.

6. After students are finishing their initial models, pass sticky notes to each group and have them comment on other groups' models. Once comments are made to each group via the sticky notes, have each group revise their model based on peer feedback.
   a. E.g.
      i. Why is this ----- here and not there?
      ii. What does ----- eat?
      iii. Where else could ----- get its energy?

7. Let the students know they have completed the initial food web, and

that they need to exchange each card with you. Have the students note each place their card is in, and then come to you to give them a "Detailed" version of that card – Repeat steps 5 and 6, then move to step 8. The Detailed version of the cards can be "data collected from another expedition" that your class just received and are combining it with the data you already had. This part of the activity ties to the Nature of Science as a social process, and that scientific knowledge can change with new data/evidence.

8. Once students have integrated the new detailed card and revised their model, you can – if time allows – create a whole class model by having each group build a layer or highlight specific food chains in the food web.

9. Have each group draw arrows connecting each organism with the animals that eat it. The arrow's direction indicates the direction of energy and material flow in an ecosystem. When the arrows are all drawn, they resemble a spider web...hence the name "food web."

10. Once all groups are complete, have them share out three food chains beginning with simple chemicals, and then include producers, consumers, carnivores and decomposers in your food chain to the class.

Debriefing the Lesson

The goal of this debrief is to help students connections to ecosystems, energy transfer, and science as a social process.

1. Ask students to remember the earlier conversation about ecosystems and food chains/webs on land, and ask them what differences or similarities they see between those found on land and those found at Axial's hydrothermal vent sites.
2. Ask students how chemosynthesis helps move energy through the food web.
3. Ask the students if their models would change if certain organisms were not at the hydrothermal vent site, e.g. Would ----- become a top carnivore if ----- was not at the vent site? How would the food web change if there was no ----- in the ecosystem?
4. Ask students how it felt to go through peer feedback and to get new data.
5. Lastly, ask the students how this model represents the flow of energy in a system and ask them to consider what the model does not show and could be changed to show that? (e.g. Where the simple chemicals came from before they came out of the vent, what bacteria may live in the vent, what other chemicals may be cycling through the system, etc.)

Scaffolding

Framing
Hydrothermal vents were recently discovered. It may be helpful to use the story of the Alvin, and the use of Research Vessels and Remote Operated Vehicles, to frame hydrothermal vents in the real world as something scientists are still learning about.

Sorting
Encourage students to sort the initial cards on their first impressions, and let them know that models are meant to be revised. Again, make a connection to this is what real scientists do as they learn more about a phenomena.

Pacing
This activity can be done with all the cards or just a few per group. This activity can also be done by adding in more cards as each group works along. I recommend starting with a few vague cards and then passing more out as the students go, and then having students replace the vague with the detailed cards in the later round.

Extension Activities

Your students may enjoy learning more about ocean research. There will be more posted to the SMILE teacher resource page and to the RCRV project page in time, so check back. Currently they can build a launch and recovery arm (like the ones used to lower the Alvin) in Mission Submersible or a Regional Class Research Vessel in Build a Boat for Scientific Research.

https://smile.oregonstate.edu/lesson/mission-submersible

https://smile.oregonstate.edu/lesson/build-boat-scientific-research

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Resources

Interactive Guide to Hydrothermal Vents:
https://divediscover.whoi.edu/hydrothermal-vents/vent-life-2/

Life at Axial Seamount and Hydrothermal Vents:
https://interactiveoceans.washington.edu/story/Biology_at_Axial_Seamount
https://ocean.si.edu/ocean-life/invertebrates/hydrothermal-vent-creatures
https://ocean.si.edu/ocean-life/invertebrates/submarine-volcanoes-and-hydrothermal-vents
https://ocean.si.edu/ecosystems/deep-sea/microbes-keep-hydrothermal-vents-pumping

Hydrothermal Vents Food Web Activities:
http://ogomarinescience.weebly.com/uploads/3/2/3/9/3239894/deep_6_vent_web.pdf
https://oceanexplorer.noaa.gov/explorations/06fire/background/edu/media/ROF06.LivingHeat.pdf
https://oceanexplorer.noaa.gov/edu/learning/5_chemosynthesis/activities/hydrothermal.html

The Story of the Alvin:
https://oceanexplorer.noaa.gov/technology/subs/alvin/alvin.html

Oregon State University's Regional Class Research Vessel Project
http://ceoas.oregonstate.edu/ships/rcrv/outreach/

Selected Videos:
How deep is the ocean?
https://www.youtube.com/watch?v=UwVNkfCov1k

Under Water Vents and Volcanoes
https://oceantoday.noaa.gov/underwatervolcanoes/welcome.html

Jason ROV Vent Animals
https://www.youtube.com/watch?v=ETRVuyj22tU&index=13&list=PLgxHFq3fMoN9jtJx4PpLzHLNpfljuLLso

NOAA Earth-Ocean Interactions Videos
https://www.youtube.com/channel/UCwYal-KFaA52F5lF9IUd9oA

Ocean Today Life on a Vent
https://oceantoday.noaa.gov/lifeonavent/