



Activity 5: Examining Samples and Asking Testable Research Questions

Overview

Alvin has just returned from sampling in the hydrothermal vent fields of the Juan de Fuca ridge. The students observe as the teacher unloads *Alvin's* basket. In the basket are pictures and specimens taken during the dive. Students use these items to practice making observations and asking testable research questions.

In this activity, students learn the difference between questions that ask for information commonly found in libraries, and questions that direct scientific research. A testable research question must include a comparison and a quantitative measure. Many of the broader questions students typically ask can be thought of as overarching questions. Overarching questions are more interesting than the more narrow “Is there a difference between ...” questions, but often tough to answer. The testable research question is intentionally narrow to drive the research methods that will be used to answer the question.

Testable Research Question

A testable research question meets two criteria:

- There must be a comparison built into the question.
- The question states (or implies) some type of quantitative data that will be collected.

A useful prompt to get students started is “Is there a difference between...”

After practicing asking testable research questions as a class, students will rotate among stations, brainstorming as many different testable research questions as they can. Questions from this activity will be used as a starting point when students begin to work on their research proposals for the SEAS competition.

Teacher Tip: This activity requires that you assemble materials for a box to simulate items collected (or used) at hydrothermal vents. We provide a list of recommended items to include in the box under “Materials.” For vent organisms, we provide pictures that may be made into picture cards for the box. Web sites listed under resources also have excellent photos for picture cards. Some items (e.g., thermometer, model ship) are included as props, to stimulate ideas for questions.

Development of Lesson (Steps):

1. Review with students the chronological developments of the cruise. Remind them that this cruise went to the Juan de Fuca ridge and that things might look different there. (A bathymetry map of the Endeavor Segment of the Juan de Fuca Ridge is provided if you want to orient your students. The names on the map refer to vent sites.) In the previous activity, they helped

Essential Concept:

- How do we ask testable research questions?
- What are some of the abiotic and biotic components of hydrothermal vent systems?

Learning Objectives:

The student will be able to:

- formulate a testable research question containing a comparison and a quantitative measure;
- state the null and alternative hypothesis for a testable research question;
- describe some of the abiotic and biotic characteristics of a hydrothermal vent system.

National Standards:

- Science as Inquiry:
 - Abilities necessary to do scientific inquiry.
 - Understanding about scientific inquiry.

Time Frame: 1 period

Materials:

Box or milk crate packed with materials representing samples from an *Alvin* dive to a hydrothermal vent. Some photos that can be used are included with this lesson. Collect or create other examples that may include:

- models of tubeworms, crabs, limpets and other HTV organisms (or picture cards of these organisms)

(continued on next page)

SEAS

Student Experiments At Sea



Activity 5 (cont.)

Materials (cont.):

- rock and mineral samples to include basalt, chalcopyrite, pyrite, anhydrate, silica (from rock and mineral kits)
- thermometer
- disposable camera
- model of a submarine, ship, and ROV
- bottle of salt water
- bottle of smelly water (e.g., bottom water from a pond)
- mud (in a ziplock bag) representing sediment
- ph strips
- hand lenses
- fish bones
- clam shells
- mussel shells
- picture cards of sulfide community (provided at end of lesson)

Resources:

Dive and Discover

For more great vent animal photos for your box: Go to Any Expedition after 4: Daily Update: Deeper Discovery: Vent biology. On the title page click to “see these amazing animals.” This gives you a chart. Click on the words and it will give you text and a photo with a little magnifying glass and the word “enlarge” the resulting photos are great. There are also a number of other photo possibilities in the slide shows throughout all of the expeditions.

<http://www.divediscover.whoi.edu/>

(continued on next page)

locate the hydrothermal vent field by interpreting temperature and density data taken from different places on the ocean floor along the ridge. Their observations were precise enough to convince the Chief Scientist to send *Alvin* down to take pictures and samples of the vents. *Alvin* has just returned to the deck of the research vessel. You and your fellow scientists are eager to see what *Alvin* has brought back from the vent field.

2. Show the class the box and tell them this is a portion of what the *Alvin* pilots collected while they were exploring the vent field. Note that *Alvin* actually contains a basket attached to the exterior of the submersible. The sampling arms can grab things and place them in the basket. “Unpack” the basket, showing students what is inside or ask for two of the Jr. Scientists (students) in the class to come up to the front and unpack it. Each item needs to be held up and quickly described so everyone in the class can see. As the contents of the basket are unpacked, place the materials in 8 different piles or bins to be used later as the students work in small groups (step 7).

3. Have the students brainstorm questions they have about the items taken from the boxes. They may do this independently in journals and then as a class. Jot down some of the questions they come up with on an overhead for all to see.

4. Ask the students how they might find answers to their questions. Some information can be found in a library or on the Internet. Remind them that scientists first discovered these systems in 1977, so there is only limited information on them. Many questions haven’t been answered yet. Students may suggest diving and collecting more samples or doing experiments. Have them describe what they might do as an experiment to answer a few of the questions. Don’t worry about whether or not these ideas for experiments fit the model they will be following in this curriculum (This is brainstorming). Use their responses and ideas as a pre-assessment of what they understand about experimental research.

5. Next tell students they will spend the rest of the class examining samples from the *Alvin* dive, making observations, and asking testable research questions. Review quantitative and qualitative observations. Tell them that a testable research question must meet two criteria.

- First, there must be a comparison built into the question. The comparison helps us identify the variable to be investigated. This is the first step toward understanding controlled experiments. Later, the students will learn that they must control as many of the variables as possible—except for the one which they are testing.
- The second criteria is that the question must imply or state the type of quantitative data that will be collected. A useful prompt is to start the question with “Is there a difference between ...” The testable research question is intentionally narrow to drive the research methods that will be used to answer the question.



Activity 5 (cont.)

6. As a class, have the students make quantitative and qualitative observations about each item and, after practice, ask testable research questions about things that were in the box. After each question, ask them whether or not the question meets the two criteria. What is the comparison? What is the quantitative measure? Continue the process as a class until you feel that most students understand how to ask a testable research question.

7. Place the 8 containers or bins of basket samples in 8 different stations around the room. Have students work in groups of 4 to generate as many testable research questions as they can. Depending on how unique the material is in each of the 8 bins, you may or may not want to rotate the bins. Groups need 10-15 minutes to generate questions. Challenge them to come up with original and interesting questions, not ones with obvious answers. A list of testable research questions is included below to give the teacher ideas. Do not give this list to the students. Let them come up with their own questions.

8. At the end of 10 or 15 minutes, ask the students to put all the materials back in the bins. Give the groups two minutes to pick out their two best testable research questions. At this point, the only criteria for best is that they have a comparison, a quantitative measure, and it's interesting to everyone in the group.

9. Ask a spokesperson from each group to read their two best questions to the class. The teacher may want to keep a list of these on the overhead or a piece of butcher paper. Improve any questions that do not meet the criteria. This list of best testable research questions will be a useful reference for future lessons and when planning the Student Experiment At Sea.

10. Last, tell students that scientists state two hypotheses to test as they investigate the question. These two hypotheses include all possible outcomes. The first is called the Null Hypothesis. This hypothesis states that there is no difference between the two conditions being compared. The Alternative Hypothesis states that there is a difference between the two conditions being compared. Emphasize that these hypotheses are very different from predictions. They do not state what the scientists expect to happen. Thus, they are unbiased hypotheses. During Cruise 5, students will learn that scientists look at results to see whether or not the data can disprove the null hypothesis. It is not necessary for students to understand this point now. It is important for them to learn to state null and alternative hypotheses.

11. Have each group write the null and alternative hypotheses for each of their two best research questions.

Resources (cont.):

NOAA Sites

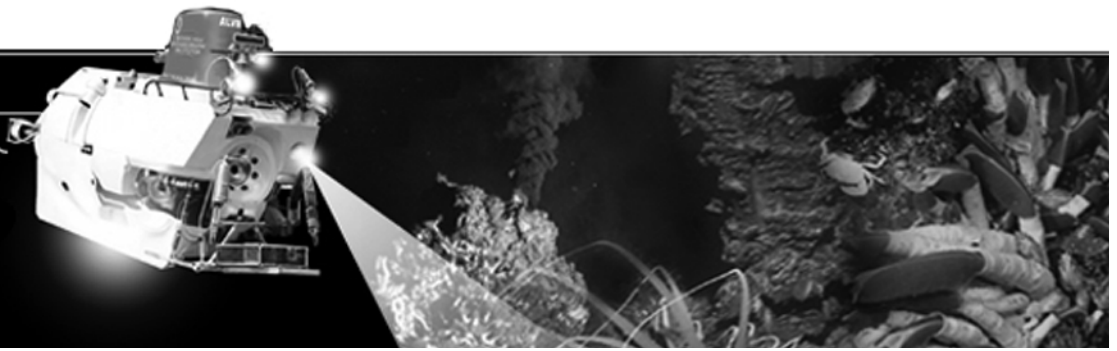
This site has many good images of vent animals and hydrothermal vents

<http://www.pmel.noaa.gov/vents/nemo/>

The Truth About Science. by

Kathryn Kelsey and Ashley Steel,
NSTA press, 2001.

Background information in *The Truth About Science*, Part 1, Information versus Research Questions and Hypothesis versus Null Hypothesis, pages 3-4.
Science Boxes in *The Truth About Science*, pp. 18-24



Activity 5 (cont.)

Possible Testable Research Questions

- Is there a difference in temperature at the top of vents and at the bottom of vents?
- Is there a difference in the number of tube worms at the top of vents and at the bottom of vents?
- Is there a difference in the hydrogen sulfide concentration in the water around active vents and inactive vents?
- Is there a difference in the number of animals around an active vent and an inactive vent?
- Is there a difference in the density of water near the vents and away from the vents?
- Is there a difference in the number of crabs near vents and away from vents?
- Is there a greater percentage of snails or limpets on top of the tube worms?
- Is there a difference in the temperature of sea water in dark areas (no light) and light areas?
- Is there a difference in the size of tube worms on the top of vents and at the bottom?
- Do limpets spend more time (possibly eating) on bacterial mats or on tube worms?

Discussion Questions:

1. Describe what you think life is like for a crab at a hydrothermal vent. How do they live? What do they eat? How do they find their food? How do they protect themselves? What is the environment like 2 miles below the ocean surface?
2. Develop 3 testable research questions to help understand the following broad question: How does temperature affect where tube worms live?
3. State the null and alternative hypotheses for each of the testable research questions from discussion question 2.
4. Describe procedures for an experiment you could do for one of the testable research questions you asked in the lesson.