

LESSON 3 Ecosystem in a Bottle

Important Note to the Teacher: This is a review of the Introduction to Lesson 2. This lesson, like the previous lesson, involves observation and experimentation with guppies, which are vertebrates. Fish are an important part of any aquatic ecosystem, thus the guppies are included in this activity, but they are optional. While living organisms provide opportunities for students to develop inquiry skills such as observation and comparison, there are also responsibilities for appropriate and humane care of the fish. When bringing animals into the classroom, a conscious effort must be made to provide guidance for students to develop an understanding of and value for life and living organisms. In addition, if you choose to use guppies or any organism, they are **never** to be released in our streams or rivers as many of the items in the aquarium are actually invasive species to Hawaiian waters.

The guppies must be provided with appropriate daily care so that they remain healthy during the course of the experiment and should not be subjected to pain or discomfort. Students need to be supervised by a teacher that understands the safe and responsible use of animals in the classroom and who understands and follows Hawai'i Department of Education policies and other relevant regulations.

Lastly, teachers must develop and implement a plan for the future care of the guppies following the study. (Adapted from the National Science Teacher Association's 2005 Position Paper: "Responsible Use of Live Animals and Dissection in the Science Classroom")

Proper care of guppies includes: 1. Feeding them daily, i.e. making sure there is a source of food such as elodea, or providing fish food flakes, 2. The temperature of the water must be between 72° and 82° F., 3. Change approximately 1/3 of the water every 1 to 2 weeks, or as needed to keep the water in good condition, 4. Create a happy or natural environment by adding things like gravel and plants to the tank. Care of the guppies must be provided daily, including weekends, holidays, and other times school is not in session. When the experiment is over you must continue care of the guppies in the classroom or implement another plan for the continued proper care of the guppies, as they cannot be re-introduced into Hawai'i's environment. Please see <http://www.habitattitude.net/> for guidance on aquarium disposal.

For further information regarding current policies and regulations in Hawai'i, contact the Science Section of the Instructional Services Branch of the Office of Curriculum, Instruction, and Student Support at the Hawai'i Department of Education.



Lesson at a Glance

In Lesson 3, students continue to study interactions among aquatic plants and animals in the class' mini-ecosystem bottle aquarium. The class will design and carry out an experiment to find out how plants and animals in a bottle aquarium interact with each other. The class' bottle aquarium is referred to throughout the unit and evidence from the experiment is used in the unit's final lesson.

Lesson Duration

Two 45-minute periods plus three 15-minute periods

Essential Question(s)

What is the role of a testable hypothesis in an experimental procedure?

What is the role of scientific observation in an experimental procedure?

How are observations different from inferences?

Key Concepts

- Experiments and experimental procedures are designed to test a hypothesis.
- Observations and inferences are very different from one another. An observation is what is observed through the senses. An inference is what is done with that observation, such as drawing a conclusion, or offering an explanation for it.
- An ecosystem includes plants, animals, and their physical, non-living environment.

Instructional Objectives

- I can describe the different roles the organisms will play in the bottle aquarium ecosystem.
- I can formulate a hypothesis for the aquarium bottles, and create experimental procedures to test that hypothesis (using a control bottle).
- I can make observations of the aquarium bottles, and draw inferences from those observations about the interactions and status of the ecosystem.

Related HCPSIII Benchmark(s):

Science SC.4.5.2
Describe the roles of various organisms in the same environment.

Science SC.4.1.2
Differentiate between an observation and an inference.

Science SC.4.1.1
Describe a testable hypothesis and an experimental procedure.



Assessment Tools

Benchmark Rubric:

Topic		Scientific Inquiry	
Benchmark SC.4.1.1		Describe a testable hypothesis and an experimental procedure	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Create a testable hypothesis and an experimental procedure to test it	Describe a testable hypothesis and an experimental procedure	Identify, with assistance, a testable hypothesis and an experimental procedure	Recognize, with assistance, a testable hypothesis or an experimental procedure

Topic		Scientific Knowledge	
Benchmark SC.4.1.2		Differentiate between an observation and an inference	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Explain the difference between an observation and an inference and give examples	Differentiate between an observation and an inference	Provide examples of observations and inferences	Define an observation and an inference

Topic		Unity and Diversity	
Benchmark SC.4.5.2		Describe the roles of various organisms in the same environment	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Analyze how the roles of different organisms affect their interaction in the same environment	Describe the roles of various organisms in the same environment	Identify a few organisms and their role in the same environment	Recall, with assistance, very few organisms and their role in the same environment

Assessment/Evidence Pieces

Lesson

- Student Worksheet 1– *Proposal for Our Bottle Aquarium Experiment*
- Student Worksheet 2 – *Daily Observations and Inference(s)*



Materials Needed

Teacher	Class	Group
<ul style="list-style-type: none"> None 	<ul style="list-style-type: none"> Four to eight, clear two-liter soda bottles (another transparent plastic container may be substituted) You will need 2 bottles to make one bottle aquarium. These bottle aquariums will be used for the class experiment. Possibly one will serve as the control, in the case the original aquarium does not suit the experiment. Water that has sat out for at least 24 hours (This is important to allow chlorine in tap water to settle or evaporate) Light source (do not put the bottle aquarium in direct sunlight as it will overheat the water.) Guppies (enough for at least one guppy per bottle, but recommend additional guppies if that is the variable that is going to be changed) Elodea plants (also called anacharis and can be purchased at pet stores) Duckweed Fresh water snails Gravel, pre-rinsed, so that there is no mud or sand, but enough to fill the bottom of the bottles and hold the Elodea plants in place Thermometers Scissors Waterproof marker Optional: aquarium aerator, with tubing and airstone, timers, rulers. 	<ul style="list-style-type: none"> Student Worksheets <i>Bottle Aquarium Experiment Proposal and Bottle Aquarium Observation Records</i> (additional copies of second record sheet may be copied as needed).

NOTE to Teacher: The experimental aquariums can be put together with the whole class or in groups (in Section IV. *Making hypotheses and designing experiments*)

Instructional Resources

Student Worksheet: *Bottle Aquarium Experiment Proposal*

Student Worksheet: *Bottle Aquarium Observation Records*

Suggested reading for the safe use of animals in the classroom:

Kwan, T., and J. Texley. National Science Teachers Association. 2002. *Exploring safely; A guide for elementary teachers*. Arlington, VA: NSTA Press.

Institute for Laboratory Animal Research (ILAR) Principles and Guidelines for the Use of Animals in Precollege Education at

http://dels.nas.edu/ilar_n/ilarhome/Principles_and_Guidelines.pdf

Student Vocabulary Words

biodiversity: the diversity, or variety, of plants, animals, and other living things in a particular area or region.

control: in a control, none of the variables are changed, all variables are kept constant. Controls help scientists make sure that the variables they are changing in the treatments are what is producing results. For example, if the control and the treatment has the same results, like all the animals died, one would conclude that it was not an effect of the treatment but something else, like bad water perhaps.

hypothesis: an idea that can be tested by an experiment or an observation.

inference: the process of arriving at some conclusion that possesses a degree of probability relative to the situation.

observation: an act of viewing or noting a fact or occurrence for a scientific or other special purpose.

variable: this is what is being tested in the experiment. So if the question was how temperature affected plant growth, the control would be at ambient temperature and the treatment would be at an elevated or decreased temperature. The variable being tested would be temperature.

Lesson Plan

Lesson Preparation

- Review the Science Background provided in the Unit Overview.
- Please read the *Important Note to the Teacher* at the beginning of this lesson. Prepare to review the ethical treatment of living things with the students in regards to the bottle aquarium activity. As guppies are vertebrates, extra caution and care must be afforded them. You may choose not to have the guppies. Please refer to the *National Science Teachers Association Position Statement: Responsible Use of Live Animals and Dissection in the Science Classroom* online at <http://www.nsta.org/about/positions/animals.aspx>. Also, check out the Institute for Laboratory Animal Research (ILAR) Principles and Guidelines for the Use of Animals in Precollege Education at http://dels.nas.edu/ilar_n/ilarhome/Principles_and_Guidelines.pdf. You may also want to check with the Education Specialist for Science in the HIDOE Office of Curriculum, Instruction and Student Support if you have questions about this.
- Please see <http://www.habitattitude.net/> for guidance on aquarium disposal.
- From the beginning remind students that guppies, if you choose to use them, and other items in the aquarium are actually invasive species to Hawaiian waters and are never to be released in our streams or rivers.
- Collect and organize materials for the bottle aquariums. Set each material on a different lab table for the students' observation activity.
- Review and make copies of Student Worksheets *Bottle Aquarium Experiment Proposal* and *Bottle Aquarium Observation Records*, one per student.
- You will need at least 4 2-Liter bottles. These will be for the class experiment. Refer to the instructions in Lesson 2 for creating the bottle aquariums. For this lesson, the bottles aquariums will contain experimental treatment aquaria based on the experiment the class decides to do.
- For the control bottle aquarium, you may want to use the bottle aquarium used in the classroom for observation in Lesson 2. If the experiment requires it, create a new control to suit the required conditions.

I. *Preparing to Design an Experiment for the Bottle Aquarium Mini Ecosystem*

- A. Pre-note: DOE teachers and students will not use a guppy or any vertebrate species for this or any exercise.
- B. Refer to the classroom bottle aquarium the students have been observing in Lesson 2. Review that the aquarium is a model of a small ecosystem that includes non-living physical (abiotic) factors, as well as living plants and animals. Go over the physical factors they have been observing:
- Whether the aquarium contains freshwater or seawater.
 - The temperature of the water.
 - The amount of sunlight or artificial light.
 - Whether there is gravel or sand, or no bottom material (substrate).
 - Amount of oxygen in the water.
- (Note that these are all variables that can be manipulated in an experimental design to test for an affect, if there is no pain or discomfort caused to the animals.)
- C. Review, the terms *producers*, *consumers*, and *decomposer* from the previous lesson. Discuss with students the role of green plants in photosynthesis and that, in natural ecosystems, some animals and bacteria act as decomposers to recycle waste.
- D. Tell students that they will be designing an experiment to determine how plants and animals in a bottle aquarium interact with each other. Refer to the aquarium ecosystem that they have been observing: a bottle aquarium containing elodea, duckweed, guppies (optional), and snails.
- 1) Their mission is to devise an experiment to observe and gather evidence to find out how these plants and animals interact with each other as producers, consumers, and decomposers. The goal of the class is to develop a food web that is based on the experimental evidence gathered.
 - 2) Add to the KWL chart. Ask more open-ended questions about the bottle aquarium to stimulate students' thoughts in developing questions for the investigation. Using the same KWL chart, record what students know (under K), and their questions about organisms and interactions (under W).
 - 3) Discuss with students examples of how a question can be stated as a hypothesis and then tested through their experiments. The goal is to have the students come up with a testable hypothesis that can be tested by creating a bottle aquarium with the experimental test conditions needed. Keep in mind we are working with live organisms.
 - 4) Ask whether their suggested example is *testable*. Decide how many variables are involved. A suggested *If-then-because* approach is shown in the following table.
 - a. Example 1 focuses on the variable snails. The question is *What would happen to the plants, if you added more snails to the aquarium?* To be *testable*, only one variable at a time can be changed and the *if* part of the statement gives ideas about the experimental test conditions. The question "*What would happen to the plants, if you added more snails to the aquarium?*" would be testable in this example. You would also have to control for production of the plants, make sure the sunlight and other conditions are the same. Are the plants growing faster than the snails can eat them? If so, the amount eaten by snails may not be noticeable if the plant grows quicker.
 - b. Example 2 focuses on 1 variable: sunlight. Point out that now the underlying question in Example 2 is *How do the plants grow when in indirect natural sunlight versus artificial light?* Help students to refine Example 2. Related questions include: *Is there more elodea growth with sunlight or artificial light?* This question suggests ways to vary the experimental conditions, as for example: *Will placing the test aquarium away from any sunlight cause the elodea to stop growing? How does it compare to the aquarium getting natural sunlight?*

IF (Conditions)	THEN (Hypothesis)	BECAUSE (Rationale)
Example 1: If more snails are in an aquarium with elodea, and duckweed,	there will be less elodea and duckweed	Snails eat plants.
Example 2: If there is natural sunlight and water,	the elodea plant will grow quickly	Because the elodea plant is an aquatic plant that thrives on natural sunlight.

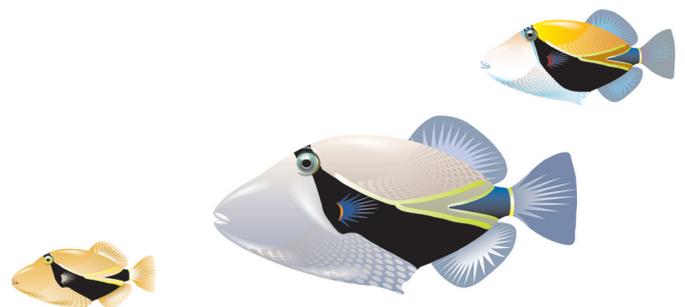
II. Preparation for the Bottle Aquarium Experiment

- A. Review and discuss again the ethical treatment of living things.
 - Explain that since they will be handling living organisms, they must do so respectfully and carefully. Part of being a good scientist is making sure that we treat all life with kindness. All living things need to be handled with consideration. Ask students what *ethical treatment* means for carrying out their experiment.
- B. DOE teachers and students will not use a guppy or any vertebrate species for this or any exercise.
- C. Explain to the students that when setting up a scientific experiment, they will need to follow the proposed experimental plan that the class will design together.
- D. Refer back to the classroom bottle aquarium. Check to make sure that the students understand what is the control, and what is an experimental variable.
 - 1) Be sure to label the aquarium.
 - 2) Continue observing the bottle aquarium daily.

III. Making hypotheses and designing experiments

Refer back to the observations made in Lesson 2. Make the connection that making observations are a part of what good scientists do, that observations are the basis for making hypotheses and designing experiments. Scientists observe nature and make inferences that lead to hypotheses, they don't come up with the questions and then observe nature and then test something. Using their observations, the students are then to come up with some questions and probably some really interesting ones! During the observation periods, the teacher can talk with them about a new variable, like temperature, exposure to light (real vs. artificial), presence and function of the gravel (to hold the bacterial community, decomposers), oxygen, consumers, producers, invasive species for that matter since all the organisms in the aquaria are invasive to Hawaiian native streams. At this point they can formulate a testable experiment and you and the class can construct the treatment aquaria. They can compare the treatment to the control, or the original observation aquaria in the class.

NOTE: As you work with the groups, keep in mind that you are going to choose one hypothesis to use for the whole class. This group activity is important for the students to get a good understanding of what is involved in making hypotheses and designing experiments.



- A. Organize students into groups. Each group is to:
- 1) Select a question to ask, and write it out.
 - 2) State their hypothesis using *if-then-because* thinking.
 - 3) Share their ideas with others in the class.
 - 4) Help critique the hypothesis and experimental ideas from all groups in the class.
- B. Choose a hypothesis from all the ideas in the groups to use for the whole class. Maybe have the class vote on one or choose one that you think will work best for their learning experience and the goals of the lesson. If they are unable to come up with one, use one of the examples provided above.
- C. On chart paper, write the experiment or question that has been chosen.
- D. Have the class help you with a written plan of the experiment using the bottle aquarium already in the class as the control, and after creating the plan, construct either one or two additional bottle aquariums to test variables. (The terms variables and control are part of the 5th grade benchmarks. It will be introduced in this lesson, however mastery is not expected until grade 5). Work with the class as a whole, or have the groups discuss each part of the plan first. On the chart paper, the written plan should include:
- 1) State the question.
 - 2) State the hypothesis using the *if-then-because* format.
 - 3) Show the experiment in the form of a sketch that includes a control and clearly identifies the organisms involved.
 - 4) A specific list of the number and size of organisms in each bottle aquarium.
 - 5) A list of equipment or supplies needed.

Post the chart paper on the wall in the classroom, so the class can refer to it throughout the lesson.

- E. Now that the class knows what the plan is and what is needed to complete it, construct the treatment aquaria with the class. You may want to construct a few bottle aquariums or have the groups construct their own aquariums with the experimental variables decided upon, so that the groups can observe and collect data simultaneously more easily. Depending on the size of your class and availability of materials, the number of aquariums you construct can vary without compromising the activity.

SAFETY: If you have the groups construct their own bottle aquariums, it is suggested you cut the bottles for them. Tell students to use caution around the cut edges of the plastic bottles. They can be very sharp. Have students wash their hands after handling the live organisms.

- F. Although the whole class is doing the same experiment, have the groups create the data table in which to record written and drawn observations. (A possible data table is included on the student worksheet, however, if time permits, allow students to create their own table to think about what they are looking for.)
- G. Review and discuss the collected data with the class and make conclusions based on the data.

IV. *Observations versus Inferences*

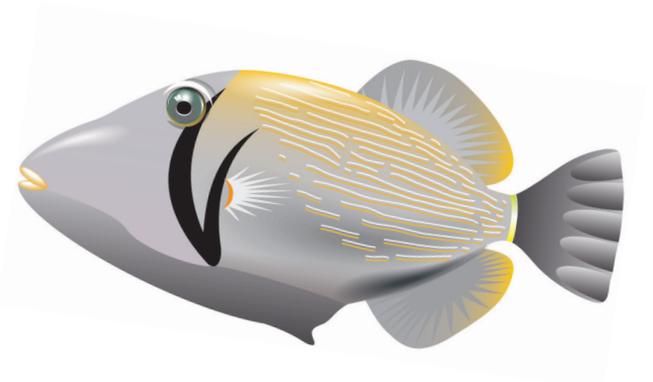
- A. Write the terms *observation* and *inference* on the board. Explain to the class that an observation is a statement or sketch of what is observed through the senses; an inference is a logical conclusion based on evidence. An inference, however, may not be a scientifically sound conclusion.
- B. Give the students examples, as follows:
- 1) Suppose that there was a student in the class named Tim, and that he wore green four out of five days last week. Help students to come up with at least two possible inferences, ask what is the evidence for each of these possibilities, and what kind of evidence would be needed to go from an inference to a definite scientific conclusion:
 - a. Tim's favorite color is green. (Evidence: because he wears it so much.)
 - b. Tim wears green because that is the color of his favorite sports team.
 - c. Tim's green clothes are the easiest to launder, so he wears them more often than other clothes.
 - d. Tim was celebrating St. Patrick's day.
 - e. Tim does not have a real reason. (If we had observed Tim for several more weeks, we would have seen that Tim varies the colors that he wears.)
 - 2) Check for understanding with the following:
 - a. My cat did not like his food because he always left at least half of it on his plate. (*inference*)
 - b. Before crossing the street the two girls looked left and right two times. (*observation*)
 - c. When the dog barked, Mom looked scared (*observation*). Mom looked scared because the dog barked (*inference*)

V. *Revisit KWL*

Ask students to update their KWL chart. *Were your questions answered? What other questions do you have? What have you learned?*

Extended Activities

1. Assign students to do independent research on marine ecosystems. Their research needs to include a picture, and labeled biotic (living factors) and abiotic (non-living factors) that affect that ecosystem.
2. Visit a public aquarium or pet store that sells freshwater and saltwater fish and other organisms. While there, make observations about the feeding behaviors of animals, and the presence or absence of plants in the aquariums.



Suggested References

<http://www.fi.edu/tfi/units/life/habitat/habitat.html> (Provides information on different ecosystems and habitats on land and in the ocean.)

<http://www.globalchange.umich.edu/globalchange1/current/lectures/klings/ecosystem/ecosystem.html> (Provides information on ecosystems that goes into details about biotic and abiotic factors.)

<http://www.epa.gov/bioiweb1/aquatic/marine.html> (Provides general information about different marine ecosystems.)

<http://www.biodiversityproject.org/biodiversity.htm> (Includes general information about biodiversity, and why it is important.)

<http://www.abheritage.ca/abnature/Ecosystems/intro.htm> (Provides information about ecosystems and food webs.)

<http://www.bottlebiology.org/> (Homepage for additional information about using bottles in biology lessons.)

<http://www.learner.org/channel/courses/essential/life/bottlebio/> (Includes additional lessons using soda bottles.)

<http://library.thinkquest.org/11353/ecosystems.htm> (Thinkquest activity that has students explore different biomes and aspects of an ecosystem, food webs, and cycles.)

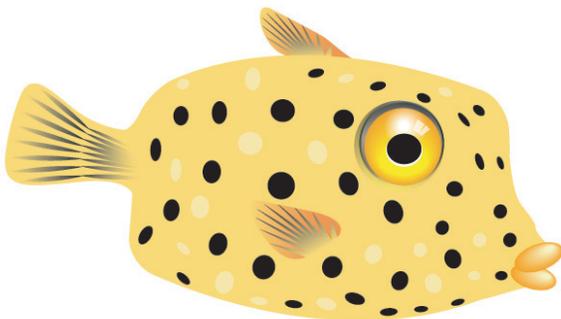
Kwan, T., and J. Texley. National Science Teachers Association. 2002. *Exploring safely; A guide for elementary teachers*. Arlington, VA: NSTA Press. (Information on the safe use of animals in the classroom.)

Institute for Laboratory Animal Research (ILAR) Principles and Guidelines for the Use of Animals in Precollege Education at http://dels.nas.edu/ilar_n/ilarhome/Principles_and_Guidelines.pdf (Information on the safe use of animals in the classroom.)

References and Resources Used by Writers

<http://mckkc.edu/longview/ctac/psych1i.htm> (Used to provide examples concerning observations and inferences for behaviors that can be practiced with the class.)

<http://www.eduref.org/cgi-bin/printlessons.cgi/Virtual/Lessons/Science/Ecology/ECL0014.html> (Includes a basic bottle aquarium lesson plan.)



LESSON 3 Bottle Aquarium Experiment Proposal

1. Group Members: _____, _____,
_____, _____, _____

2. Purpose (stated as a question)

3. Hypothesis:

If _____

Then _____

Because _____

4. Materials we will need: _____



5. Our proposed experiment:

Sketch of the Control Bottle Aquarium	Sketch of the Experimental Bottle Aquarium

6. What do you plan to observe and record every day?

Please submit your proposal to your teacher.

LESSON 3 Bottle Aquarium Observation Records

1. Group Members: _____

2. Our Purpose: _____

3. Our Hypothesis: **If**
Then
Because

Recorder	Time/Date	What we did	What we observed



Recorder	Time/Date	What we did	What we observed