



Crawl into Inquiry-Based Learning

Hermit Crab Experiments

Maya Wolf and Alix Laferriere



Abstract. There is a particular need for inquiry-based lessons in the early elementary grades, when students are starting to develop their analytical skills. In this article, the authors present a 2-tiered inquiry-based lesson plan for 1st and 2nd grades that has been successfully used by graduate teaching fellows involved in the National Science Foundation GK–12 program at the Oregon Institute of Marine Biology (OIMB), University of Oregon. This lesson involves the use of live marine or terrestrial hermit crabs. The first tier of the lesson covers the anatomy, general ecology, and classification of the hermit crabs, with students making detailed observations and asking questions about their live subjects. The second tier is an experiment to test a question commonly raised by students: Do hermit crabs like to live on sand or on rocks? Students use this question to design and choose an experimental setup, make hypotheses, record and report results, evaluate their experiment, and suggest possible improvements.

Keywords: experiment, hermit crabs, inquiry, observations, questions

The goal of scientific inquiry in classrooms is to stimulate students to think in ways similar to those of practicing scientists, with students addressing questions, developing hypotheses, designing experiments to test hypotheses, deriving answers, discussing results

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with peers, evaluating the processes, and developing more questions to address (National Research Council [NRC] 1996). There is a considerable amount of inquiry-based curricula and pedagogical instruction for upper-grade-level teachers because higher-grade students are considered more receptive to open-ended cognition lessons (Furtak 2006, 453). There is, however, a growing emphasis on integrating scientific inquiry into early elementary classrooms (American Association for the Advancement of Science [AAAS] 1993, 6; NRC 1996, 27–54; National Science Resource Center 1997, 7–30; Newman et al. 2004, 257).

The National Science Foundation Graduate Teaching Fellows in K–12 Education (GK–12) program enables graduate student fellows from diverse science, technology, engineering, and mathematics (STEM) backgrounds to teach in K–12 classrooms. GK–12 fellows from the University of Oregon’s Institute of Marine Biology (OIMB) teach marine science in early elementary classrooms (grades K–6) on the southern Oregon coast. The initial curriculum was adopted from the Marine Activities, Resources, and Education (MARE; California Board of Regents 2009) curriculum, with each grade focusing on a different marine habitat. Fellows also develop their own lessons to integrate into the habitat-focused MARE curricula. A number of inquiry-based marine science lessons targeted toward early elementary students have been developed from this program. Because the fellows have easy access to local habitats and marine animals provoke innate intrigue for students of all ages, live animals are often used as subjects for these lessons. Live animals are not only exciting experimental subjects in the classroom, but also a means for teachers to cultivate and share with their students a sense of responsibility and respect for organisms.

We recognize that most teachers do not have easy access to live marine animals and therefore have included

both marine and terrestrial experimental subjects in this lesson. Hermit crabs are ideal test subjects because they are accessible, hardy, and exciting to observe—and do not have the escape-artist tendencies of regular crabs. Marine hermit crabs can be found during low tides in tidepools and on coral reefs and can be kept for months in saltwater aquaria. Terrestrial hermit crabs are found in the tropics on sandy beaches and nearby trees. Although they live on land as adults, terrestrial hermit crabs are tied to the ocean during development because their young (or *larvae*) hatch, swim, and feed in the ocean. Terrestrial hermit crabs may be purchased at pet stores and kept in classrooms for years.

This two-part lesson uses hermit crabs as subjects for an inquiry-based teaching and learning unit for first and second grades. The first part of the lesson includes anatomy, ecology, and the features of the crabs that place them in the subphylum Crustacea. (For similar ideas on introducing and observing hermit crabs see MARE's "Hermit Crabs in the Classroom"; Regents of the University of California 2002). This first lesson gives students the opportunity to develop knowledge of the experimental subjects, as well as time to make observations and develop questions about the hermit crabs. Students also develop a list of rules on how to handle live animals respectfully. The second lesson is an experiment designed to test a question developed by students, with guidance from teachers. In our case, we tested this question: Do hermit crabs like to live on sand or on rocks? Students design an experimental setup, vote on the design to use, make hypotheses, record results, and orally report their results to the class. Both lessons have been taught more than 50 times in first- and second-grade classrooms in the Coos and Curry County School Districts, Oregon. The lessons also address a variety of national science principles, standards, and benchmarks (see Appendix A).

Hermit Crab Biology (Time = 1 hr)

Background

Scientists sort animals into specific groups because the animals have traits in common. Hermit crabs are crustaceans; like all members of this group, they have segmented bodies, jointed legs, and exoskeletons. Both marine and terrestrial hermit crabs have four life stages (three developmental stages and the adult stage). During the first two stages, they swim in the water column before metamorphosing, or changing, into juveniles and returning to the adult habitat. To help them survive in their habitats, the adults have specific adaptations, such as claws for defense and food acquisition and living in a protective snail shell to protect the crab's soft body. As the crab grows, it must find a new, larger snail shell.

Student Goals

In this activity, students should do the following:

- make detailed observations,
- practice scientific labeling, and
- develop testable questions.

Materials

- Hermit crab and crustacean transparency (see Appendix B)
- Plastic containers to hold groups of hermit crabs
- Hermit crab poster showing crabs in and out of the shell (see links listed under Resources for drawings of hermit crabs inside and outside of their shell)
- Laminated hermit crab anatomy labels (see Appendix C)
- Hermit crab biology worksheet and transparency (see Appendix D)
- Magnifying glasses (one per student)
- Live hermit crabs (one per student or group)

Collecting crabs from rocky shores or terrestrial sites may require a permit from your state department of fish and wildlife, which may take weeks to months to obtain. However, terrestrial hermit crabs can be purchased from a local pet store (see the link for terrestrial hermit crab care listed under Resources). Marine hermit crabs require a habitat of chilled, aerated water such as a saltwater aquarium. They can be maintained for brief periods of several hours in buckets of seawater placed in coolers with ice and aerated with air stones and bubblers.

Procedure

Begin with a KWL (i.e., what we know, what we want to know, what we have learned) chart to see what students already know about hermit crabs. Growing out of their shell nearly always comes up. When it does, have the students imagine they are baby hermit crabs. Describe how, as a crab grows, its shell starts to feel tight, like clothes for which a person has grown too big. Then describe how the crab searches for a larger shell, uses its claws to fight with another hermit crab for it, backs its soft abdomen into the new shell, and holds on to the new home with little legs. Discuss the word *adaptation* (a part of an animal or way it behaves that helps it to survive), and ask for hermit crab examples of adaptation.

Use the crustacean classification overhead (see Appendix B) to address the *subphylum*, or broader group, that includes hermit crabs. Discuss why scientists sort some animals together and what traits (e.g., body parts) crustaceans share (e.g., segmented body, jointed appendages, and an exoskeleton). Discuss why these traits might be beneficial. To illustrate the importance of jointed appendages, for

example, have students pretend their legs have no joints and try to walk around that way. Ask whether a hermit crab has the traits listed and what other animals scientists might put in the same group. List students' answers on the board, adding your own at the end (e.g., crabs, shrimp, lobsters, beach hoppers, crayfish, and barnacles). Then have the students gather around a large drawing of a hermit crab inside and outside of its shell. Draw an arrow to a part of the crab and ask the name of that part. Have students stick the appropriate label on the poster (see Figure 1).

Discuss the importance of being respectful to live animals and have students make their own rules for handling live animals. Write the rules on a piece of poster board to display in the classroom, and ask students to commit to the rules by raising their hand.

Give one hermit crab to each student or group and one magnifying glass to each student. Pass out an observation worksheet with questions designed to encourage students to make close observations about their hermit crabs (see Appendix D). Give students time to observe the hermit crabs through the magnifying glasses (see Figure 2). Then ask the students to share their observations and questions. Depending on the students' grade and reading levels, it might be helpful to lead the students through the worksheet on the overhead, question by question. After cleanup, go back to the KWL chart and make a list of questions the students would like to answer. We often discuss basic ecology because many of the questions concern the animals' general habitat and diet. If time permits, go over each question, asking whether it is testable. Some considerations to help students decide whether a question is testable include the following: Could we design an experiment to test that question? Can we do it in the classroom? What would we measure or look for during the experiment that would give us the answer to our question?

Hermit Crab Experiments (Time = 1 hr)

Background

The second lesson is inquiry based and allows students to design and carry out an experiment to test a question developed in the previous hermit crab biology lesson. This lesson uses an example question often asked by students: Do hermit crabs like to live on sand or on rocks? This question often arises during discussions of different types of hermit crabs living on rocky shores and sandy beaches and works for both terrestrial and marine hermit crab test subjects. For terrestrial hermit crabs, you can use additional substrates found in their tropical habitats, such as coconut fibers, leaf litter, and bark, as well as sand and rocks. Terrestrial hermit crab care Web sites (see Appendix E) and test experiments suggest that, although land-based hermit crabs like to climb on large rocks, they prefer sand to small gravel rock substrate.



FIGURE 1. Students help label a drawing of a hermit crab inside and outside of its shell.



FIGURE 2. A student makes close observations of a hermit crab using a magnifying glass to help answer specific questions about hermit crab anatomy and behavior.

In this activity, we emphasize for the students that scientists design experiments to test a question, and they often make a hypothesis—an explanation of what they think will happen or what they think the experiment's results will be. The hypothesis is not a random guess. Rather, it is based on observations and prior knowledge about the subject. A valuable class exercise to stimulate scientific thought processes is to reevaluate the experimental design after running the experiment and discussing what could be changed to improve it. A good resource for understanding the process of science is the Understanding Science Web site (see Appendix E).

Student Goals

In this activity, students should do the following:

- learn the terms *experiment*, *hypothesis*, *results*, and *conclusions*;

- ask scientific questions about hermit crabs;
- use information gained in lesson 1 to make a hypothesis about hermit crabs that can be tested in the classroom;
- design an experiment to test the hypothesis;
- report the outcome of the experiment to the class; and
- evaluate the experiment and discuss possible shortcomings and potential improvements.

Materials

- One hermit crab per student or group
- One tray per group
- Bucket of sand
- Bucket of small rocks
- Bucket of large rocks
- Coconut fibers, if using terrestrial hermit crabs (optional; purchased from pet shops or online; brand names include Forest Bedding, Bed-A-Beast, and Eco-Earth; see <http://www.hermit-crabs.com/>)
- Hermit crab experiment worksheet (see Appendix F) and overhead

Procedure

Begin with a brief review of hermit crab biology from the previous lesson. Ask where hermit crabs live, and remind students that they will be testing this question: Do you think hermit crabs like to live on sand or on rocks (or on coconut fiber, if available, for terrestrial hermit crabs)? Ask if someone can think of a way to find an answer to this question in the classroom laboratory. Discuss the term *experiment*. Draw student experimental design ideas on the board, showing where the rocks, sand, and hermit crabs would be placed. (Our students had excellent ideas, most of which included a container with some variation of rocks and sand.) Questions that help clarify students' design ideas may include the following:

- Where will we put the rocks and the sand?
- Should we use little rocks, big rocks, or a mix?
- Where should we place the test hermit crab(s)?
- How long should we run the experiment?
- Should we repeat the experiment?
- How will we be able to tell whether the hermit crab likes the sand or the rocks?

After discussing several experimental designs, have the students vote (with their eyes closed) on the experiment they think will best test the question. Once an experimental design is chosen, ask student aides to help prepare the setup on trays for each group (for an example setup, see Figure 3).

Set the trays aside to allow time to address students' hypotheses. Ask who thinks the hermit crabs will go to the sand and who thinks they will go to the rocks. Ask the students to explain



FIGURE 3. An example of an experimental setup designed by the students, with sand on one side, sand mixed with rocks on the other side, and hermit crabs placed in the middle.

their reasoning. Mention that they have just made a *hypothesis* because they have used what they learned about hermit crabs to explain what they think will happen in the experiment. Define the term *hypothesis*: a proposed explanation for what you think will happen. Then, have students use the hermit crab experiment data sheet (see Appendix F) to circle their choice of substrate and to write an explanation for their hypothesis. Because reading and writing levels vary according to grade and time in the school year, it might be helpful to go through the worksheet one part at a time on an overhead projector.

Review the rules for handling live animals from the previous lesson. It is helpful to set a few additional experiment rules (e.g., no touching hermit crabs after the start of the experiment and no bumping the table) and discuss why breaking the rules might change the outcome of the experiment. Give each group one of the trays prepared with sand and rocks. Although the general setup will be the same for each tray, you may have each group test a slight variation of that general plan (e.g., sand vs. big rocks, sand vs. little rocks, and sand vs. a mixture of big and little rocks). Hand out the hermit crabs.

Run the experiment, with individual students or groups recording the results for their hermit crabs. Repeat the experiment if time allows. Then, have one person from each group report the results for the group, and write the results on the board. As a class, discuss the results. Questions that might help this discussion include the following:

- Did your hermit crab clearly prefer sand or rocks? How could you tell?
- Did the other hermit crab(s) in your group clearly prefer sand or rocks?
- Did rock size matter? Did groups with sand and big rocks have a different result than groups with sand and little rocks? If yes, why?

- If you repeated the experiment, were the results always the same?
- Did you answer our question? Can you make a conclusion from your results?
- Are your results clear? Are results always clear for professional scientists?
- What could we change about the experiment to make it more realistic or clear?
- What would happen if we ran the experiment for a week? Would we see a different result?

Discussion

We have found that most of the student experiments did not yield consistent, predictable results, but finding results is not the aim of the lesson. The objective is to stimulate the mental processes necessary for students to come up with testable questions and experimental designs to test those questions, as well as to evaluate the experimental setup. Moreover, such ambiguous results accurately represent the true process of scientific inquiry in which scientists often use pilot experiments to refine their experimental methods.

We and other OIMB GK–12 fellows have repeatedly taught these two lessons with success in fulfilling inquiry objectives. We were impressed by the students' experimental design ideas and found that we were limited by the supplies at hand, rather than by the students' ingenuity. Also impressive were students' acute critiques of the experimental design and their suggestions for improvements. For example, students suggested extending the duration of the experiment or turning off the classroom lights to give the hermit crabs more time or the cover of darkness to get comfortable. Other student ideas included running the experiment for marine hermit crabs with the substrate and hermit crabs in seawater, rather than out of water on a tray.

Extensions

The discussion after the hermit crab experiment about what changes could make the experiment more realistic is important and can lead to various extensions. Extending experiments to hours, days, or weeks with student monitoring, data recording, and reporting could be a great learning tool. A comparison of terrestrial versus rocky shore hermit crabs and their preferences for rocks or sand would also be an interesting classroom experiment. Another extension into hermit crab biology could address molting of the exoskeleton in crustaceans and the hermit crab life cycle, including their two different larval forms.

Nonexperimental extensions of this activity can help students learn more about hermit crabs through reading and art. Two great books for introducing hermit crab biology and life cycles are Eric Carle's *A House for Hermit Crab* (1987) and *Pagoo*, by Holling C. Holling (1985). Another extension of basic hermit crab biology is making hermit crab hats of paper

or papier-mâché that depict the association of hermit crabs with other life forms including sea anemones, seaweeds, and other marine organisms that live on the hermit crab's shell. (For more information on hermit crab associations, see online resources in Appendix E). This cross-curricular application between science and art addresses the National Standards for Visual Arts Education standard 6: Making connections between visual arts and other disciplines (National Art Education Association 1994, 15–17).

Conclusions

Hermit crabs are ideal subjects for inquiry-based experiments. Like other live animals, hermit crabs naturally stimulate students to make observations and generate questions about the biology and behaviors of these test subjects. With a growing emphasis on incorporating inquiry-based science in early elementary curricula, lessons using live subjects, such as the hermit crab experiment described in this article, might become commonplace in our classroom laboratories. The inquiry-based learning approach enables students to become comfortable asking questions and encourages them to learn a process that prepares them for scientific investigation.

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Appendix A
Standards Addressed

Ocean literacy essential principle 5: the ocean supports a great diversity of life and ecosystems

National Science Education Standards: life science (characteristics of organisms and their environments, behavior of organisms)

Standard 6: understands relationships among organisms and their physical environment

National Science Education Standards: science as inquiry

Standard 12: understands the nature of scientific inquiry

American Association for the Advancement of Science benchmarks

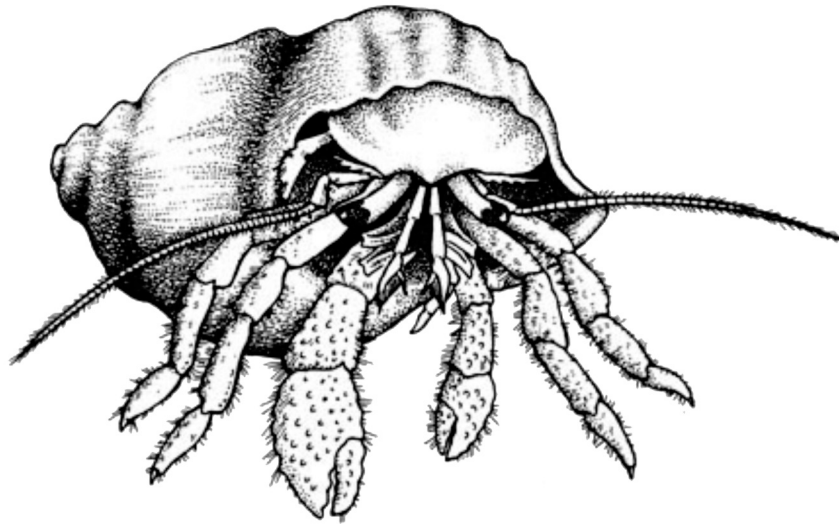
Benchmark 1b: scientific inquiry

Benchmark 5a: diversity of life

Sources. Ocean Literacy: The Essential Principles of Ocean Sciences Grades K–12 (National Geographic Society et al. 2006); *National Science Education Standards* (National Research Council 1996); and *Benchmarks for Science Literacy* (American Association for the Advancement of Science 1993).

Appendix B
Hermit Crab Biology Overhead, with Characteristics Shared by Crustaceans

Hermit Crabs



Crustacea:
Segmented Body
Jointed Legs
Exoskeleton

Sources. Hermit crab drawing from the Marine Ecology Station (www.mareco.org). Art by Iris Churcher. Reprinted with permission.

Appendix C
Hermit Crab Part Labels

Antennae	Claws	Legs	Snail shell
Little legs	Eye	Abdomen	Exoskeleton

Appendix D
Questions for Hermit Crab Biology Observations Handout

What is the color of the hermit crab's shell?
 How many legs does a hermit crab have?
 What color are the hermit crab's legs?
 How does the hermit crab move?
 How does it hold on to its shell?

Appendix E
Online Resources for Live Animal Inquiry

Additional inquiry-based lessons developed by the authors that use live animals:
<http://www.uoregon.edu/~oimb/Academics/GK12/>
 General hermit crab biology (terrestrial and marine):
http://en.wikipedia.org/wiki/Hermit_crab
 Hermit crab anatomy figure:
<http://www.enchantedlearning.com/subjects/invertebrates/crustacean/label/hermitcrab/labelanswers.sht>
 Hermit crab life cycle information:
<http://www.oceaninn.com/guides/crustacea.htm>
 Information on the scientific process (Understanding Science Web site):
<http://undsci.berkeley.edu/index.php>
 Marine hermit crab care information:
http://www.petco.com/caresheets/fish/Crab_Marine.pdf
 Terrestrial hermit crab care information:
<http://www.hermit-crabs.com/>
<http://www.thecrabbagepatch.com/faq.html>
 Hermit crab associations and symbionts:
<http://www.public.coe.edu/departments/Biology/hermit.html>
<http://www.dailykos.com/story/2008/3/14/215037/865/53/476922>

Appendix F
Hermit Crab Experiment Data Sheet

Name _____

1. Do hermit crabs like to hide in sand or rocks?

Hypothesis: Rocks Sand
 Why? _____

2. Will the size of the rock make a difference?

Hypothesis: Yes No
 Why? _____

3. What rocks, sand, or fibers do you have?

Big Rocks	Big & Small Rocks	Little Rocks
Medium Rocks	Coconut Fibers	Sand

4. Results: What did your hermit crab do?

Hid in rocks	Hid in sand	Hid in coconut fibers	Did not hide
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