GO WILD IN NEW YORK CITY

Inquiry project: Behaving Like Bugs

In this lesson students will conduct a research study to investigate the behavioral responses to light and humidity of different city bugs such as mealworms, milkweed bugs or pill bugs. The activity is geared towards middle school students but can be tailored to accommodate either slightly younger or older students.

Learning Goals

At the end of this project, students will:

- Learn that bugs have specific preferences for light or dark, and humid or dry environments.
- Be able to design experiments to research bugs' behavioral response to external stimuli.
- Develop observational skills of bugs' behavior.
- Propose hypothesis regarding bugs' behavior.
- Be able to record careful observations.
- Identify possible causes of error in their results.
- Interpret the results obtained in terms of their prior hypothesis.
- Propose explanations that account for their results.
- Be able to communicate their findings and conclusions to other students

Background Information

Arthropods are the most successful animals on Earth, having conquered land, sea and air, and making up over three-fourths of all currently known living and fossil organisms. They include familiar forms such as lobsters, crabs, centipedes, millipedes, spiders and insects. Arthropods are very diverse in structure, in lifestyles, and in types of habitat, but they all share an external skeleton composed of the complex sugar chitin.

Although at a first glance they might seem simple animals, all Arthropods have a complex nervous system, with a compartmentalized brain that enables them to develop sophisticated instinctive behaviors, which is very evident in social insects like bees or ants. Most arthropods show *taxis*, i.e. behaviors consisting of a directed movement of the whole animal towards or away from a stimulus such as light, a chemical compound or humidity. For example, pill bugs live best in moist conditions and usually gather together in humid places such as below tree barks. Their *taxis* makes them move towards moister environments, allowing them to find better places to develop and reproduce and ensure their survival.

In this research project students will investigate bugs' *taxis* in relation to external stimuli similar to the ones encountered by them in their natural environment, namely light

and humidity, and based on their results, propose hypothesis of which habitat would be the best for the studied organism.

Development of the activity

1. Warming-up

As an introduction to this activity, discuss with students the following questions:

What bugs have you seen in your home, school, or park? Which are you favorites and why? What do you know about them?

Have you ever observed their behavior? How do they get food? How do they mate? What places do they prefer to live?

What would you like to know about bugs?

Record students' ideas about bugs' behavior and preferred habitats on the board, which will be resumed during the investigation. Students' questions about bugs can be used at the end of the project for extension activities.

Students will then conduct their research project in small groups. Prepare in advance the following list of materials:

2. Materials (per group of students):

About 20- 30 bugs (milkweed bugs, pill bugs or mealworms work very well and can be purchased form Carolina Biological Supply Company or similar companies, but you can try with any kind of bug that you collect)
A large rectangular cake pan
A glass or acrylic lid to cover the pan, to prevent the bugs from escaping
Watch
Student's journals

* For the light vs. dark experiment:
Black cardboard to cover half of the pan
A goose neck desk lamp

* For the moist vs. dry experiment:
A big piece of cotton
Water
A warm place

3. Experiment

Explain students that they will have to investigate whether bugs (that is, the particular bug type they are going to use for the activity) prefers light or dark environments, and also whether they like better moist or dry places. Depending on the

time and resources available, each student group can conduct either one experiment or both.

Ask students how they would know whether bugs prefer light or darkness/ moisture or dryness, give them all the materials except the bugs, and allow them 15 minutes to design an experiment to answer that question. Students will have to record their experimental design and specify the question they are trying to answer (e.g. Do pill bugs prefer light or dark environments?) on their journals.

Each group of students will then present their experimental design to their peers, whom will be expected to provide them with feedback in order to improve their experiment. After the discussion, the class as a whole will agree on two experimental designs, one for each research questions, and conduct the experiments. The reason for choosing only one design per question is to increase the number of groups doing the same experiment, which will allow students to compare their results. Typical experimental designs are as follows:

<u>Light vs. dark environments:</u>

1. Place the pan on a table or any stable surface
2. Cover the pan with the glass or acrylic lid
3. Cover half of the pan with the black cardboard, in order to make it dark
4. Position the lamp on the table, illuminating the pan evenly from above
5. Carefully remove the lid and place the bugs in the middle of the pan
6. Record the number of bugs at each side (light or dark) of the pan at a 3-minute interval, for 15 minutes (quickly remove the cardboard from the dark side in order to be able to see the bugs, and place it back again).

<u>Moist vs. dry environments:</u>

1. Place the pan on a table or any stable surface, preferably in a warm place
2. Wet the large piece of cotton and place it on one side of the pan
3. Cover the pan with the glass or acrylic lid
4. Wait for about 5 minutes in order to let the water in the cotton evaporate a little and generate a moist environment in that side of the pan
5. Carefully remove the lid and place the bugs in the middle of the pan
6. Record the number of bugs at each side (moist or dry) of the pan at a 3-minute interval, for 15 minutes.

Guide the discussion of the experimental design with the following questions:

- Where should you place the bugs in order to be sure that they have equal chance to go to each side of the pan?
- How often should you record how many bugs are there on each side?
- What if some bugs remain in the middle of the pan?
- When will the experiment finish? Should you specify a time limit or not?

- What results would you expect to find if the bugs prefer dry (or moist, or light, or dark) environments?
- How would you know that the bugs are not randomly moving to each side of the pan?
- Why is it important to conduct the experiment with more than one bug? How many bugs should be enough?

Students will record their data using the following template (the numbers provided are examples):

Research question: Do mealworms prefer dark or light areas?

Number of Bugs	**0 min**	**3 min**	**6 min**	**9 min**	**12 min**	**15 min**	**Observations**
Condition 1 (ex: darkness)	0	7	9	11	12	13	Some of the bugs are not moving at all, maybe we should not count them? Check if they are in good condition.
Condition 2 (ex: light)	0	3	3	4	4	5	
Middle of the pan	20	10	8	5	4	2	

Analysis and presentation of results

Each group of students will orally present their results to the rest of the class. Then, all group results will be charted on the board and discussed. Results for each group will be compared in order to analyze the results as a whole. Make sure to include the following questions in the discussion:

* During each group presentation:
Did you find any environmental preference for your bug? Why (or why not)? Was it useful to include more than one bug per group? Did you have any special comments about what you observed during the experiment?

* Among groups:
Did every group obtain the same results? Why (or why not)?
Were there any procedural differences among the groups, such as the way measurements were taken, the bugs used, etc?
Which are the possible sources of error in this experiment? What improvements should be added in the future?

Then, analyze with students the whole class chart in order to reach a general conclusion for each experiment, and discuss advantages of making a whole class

experiment (Do the whole class results coincide or differ from each group's conclusions? What would have been different if we considered individual groups' results instead of the whole class data?)

Discuss with students the ideal habitats for the bugs studied according to the class results: Where do you think we could find this kind of organism? Ask students to draw on their notebooks an environment where they imagine that they would be able to find this kind of organisms, and have them research about their actual habitats either in the school library or using the Internet.

Finally, ask students to individually create a written report, including:

- Their experimental design
- Their results.
- Their interpretation of the results.
- Possible sources of errors in the experimental design or procedure
- Possible improvements if the experiment would be conducted again.

Assessment

This project provides various opportunities to assess students' learning (see Learning Goals) in formative and summative ways. Student's skills and conceptual understanding can be assessed through:

-Students' experimental design (formative)
-Students' performance during the bugs experiment (formative)
-Students' participation in the group discussions during the development of the experiment (formative)
-Students' presentations of results and their contribution to the whole class discussion (formative)
-Student's drawings of the habitats they hypothesize for their bugs, and their research about their actual habitats (formative).
-Students' individual final reports (summative)

Extensions

As a follow up of this activity, students can research bugs' responses to other environmental stimuli such as color or temperature (see Miller, J. (2004) Insects in the Classroom: A Study of Animal Behavior. *Science Activities*, 41(2), 24-31 for more details) and relate their results to the bugs' actual habitats.

Other interesting behavioral studies can be conducted by obtaining an ant farm (see Go Wild in New York City, page 51) and observing ants closely in order to identify the different behaviors that ants develop in their colonies. That study can be followed by a unit regarding behaviors of social insects in general. For instance, students can learn about bees' social behavior and the process of pollination and honey making, while

researching how some New Yorkers work as beekeepers, collecting honey and selling it in the local markets (see page 51).

Connection to New York City Standards

This activity addresses the following NYC Performance Standards for Middle School Science:

S2c Life Science Concepts: The student produces evidence that demonstrates understanding of regulation and behavior and response to environmental stimuli.

S5a to f Scientific Thinking: The student:

a. Frames questions to distinguish cause and effect
b. Uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena
c. Uses evidence from reliable sources to develop descriptions, explanations and models
d. Proposes, recognizes, analyzes, considers, and critiques alternative explanations; and distinguishes between fact and opinion
e. Identifies problems, proposes and implements solutions, and evaluates the accuracy, design and outcomes of investigations
f. Works individually and in teams to collect and share information and ideas

S6a to e Scientific Tools and Technologies: The student:

a. Uses technology and tools to observe and measure objects, organisms and phenomena
b. Records and storage data using a variety of formats
c. Collects and analyzes data using concepts and techniques in Mathematics Standards 4
d. Acquires information of multiple sources
e. Recognizes sources of bias in data

S7a, b, d and e Scientific Communication: The student:

a. Represents data an results in multiple ways
b. Argues from evidence
d. Explains a scientific concept or procedure to other students
e. Communicates in a form suited to the purpose and the audience

S8 a and c: Scientific Investigation: The student demonstrates competence in investigations that integrate:

a. Controlled experiment
b. Design