Chain Reaction

GRADE LEVEL: 9-11

TIME ALLOTMENT: Three 45-minute periods

OVERVIEW: This inquiry-based lesson plan will challenge students to design and conduct scientifically valid experiments to evaluate hypotheses regarding an animal's expected behavior in response to changes in its environment.

Students will first view and analyze video segments from the NATURE film "Earth Navigators" as they begin to think about animal behavior as a response to stimulus in the environment. The video clips feature many different animal species reacting to changes in the environment by migrating from one part of the earth to another. Students will predict the reasons for these migrations and will determine the stimuli that actually trigger the animals to migrate.

Following the video exploration, students will conduct reading and research to learn about isopods (commonly known as pill bugs or roly polies). The students will use the information they gather to formulate research questions having to do with the isopods' expected response to environmental stimulus. The students will design experiments that can be conducted in the classroom to test their hypotheses. They will conduct the student-designed experiments, collecting data and reporting their findings and conclusions. They will also make suggestions for future improvements in the experimental protocol.

SUBJECT MATTER: Living Environment/Biology

LEARNING OBJECTIVES:

Students will be able to:

- Draw connections between the migratory behavior of different animals and seasonal changes on Earth;
- Describe migration as an instance of behavioral response to stimulus;
- Using anatomical and environmental information, create a research question about an isopod's behavior in response to environmental stimulus;
- Create a hypothesis that addresses the research question;
- Design and conduct an experiment to evaluate the hypothesis;
- Collect data from the experiment, describe results, and evaluate conclusions.

STANDARDS AND CURRICULUM ALIGNMENT:

CONTENT STANDARD A: As a result of activities in grades 9-12, all students should develop:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

CONTENT STANDARD C: Life Science. As a result of activities in grades 9-12, all students should develop understandings of:

- Behavior of Organisms.

New York State Regents Core Curriculum Alignments
Living Environment Core Curriculum
http://www.emsc.nysed.gov/ciai/mst/pub/livingen.pdf

STANDARD 1: Students will use mathematical analysis, scientific inquiry, and engineering designs, as appropriate, to pose questions, seek answers, and develop solutions

Key Idea 2: Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

Performance Indicator 2.1: Devise ways of making observations to test proposed explanations.

Performance Indicator 2.3: Develop and present proposals including formal hypotheses to test explanations; i.e., predict what should be observed under specific conditions if the explanation is true.

Performance Indicator 2.4: Carry out a research plan for testing explanations, including selecting and developing techniques, acquiring and building apparatus, and recording observations as necessary.

Key Idea 3: The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into natural phenomena.

Performance Indicator 3.1: Use various methods of representing and organizing observations (e.g., diagrams, tables, charts, graphs, equations, matrices) and insightfully interpret the organized data.

STANDARD 4: Students will understand and apply scientific principles and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 5: Organisms maintain a dynamic equilibrium that sustains life.

Performance Indicator 5.3: Relate processes at the system level to the cellular level in order to explain dynamic equilibrium in multicelled organisms.

5.3a Dynamic equilibrium results from detection of and response to stimuli. Organisms detect and respond to change in a variety of ways both at the cellular level and at the organismal level.

Key Idea 6: Plants and animals depend on each other and their physical environment.

Performance Indicator 6.1: Explain factors that limit growth of individuals and populations.

6.1f Living organisms have the capacity to produce populations of unlimited size, but environments and resources are finite. This has profound effects on the interactions between organisms.

MEDIA COMPONENTS

Video

NATURE: *Earth Navigators*, selected clips

Clip 1: “Planetary Moves”

Introduction to four species’ migratory patterns.

Clip 2: “Monarch Migration”

The start of the monarch butterfly’s northward trek.

Clip 3: “Hungry Beasts”

Wildebeest and locusts on the move.

Clip 4: “Arctic Summer”

Many birds summer in the arctic.

Access the streaming and downloadable video segments for this lesson at the Video Segments Page (http://www.pbs.org/wnet/nature/lessons/chain-reaction/video-segments/1651/).

Web Sites

FOSSWEB: Isopods

http://lhsfoss.org/fossweb/teachers/materials/plantanimal/isopods.html

Includes general information on isopods and useful tips on how to find and keep pill bugs for the classroom

Isopod, Pillbug, Sow bug information

http://insected.arizona.edu/isoinfo.htm

Includes general information on isopods.

NCES Graphing Tutorial

http://nces.ed.gov/nceskids/help/user_guide/graph/whentouse.asp

This tutorial from the National Center for Education Statistics explains the various kinds of graphs and demonstrates how to build them.

MATERIALS

For the classroom:

- Computer and projection system for showing video clips
- Several computers for student use
  Chalkboard or whiteboard
- Isopods (pill bugs) in a terrarium or other classroom habitat (enough specimens for at least 15-20 per student group)
- Isopod Research Organizer Answer Key

Materials to be used in pill bug experiments (several of each):

- Paper towels or filter paper
- Eye droppers
- Portable Lamps
- Heat Packs
- Cold Packs
- Card stock or construction paper
- Substrate materials, e.g. sand, gravel, dirt, shredded paper, bark, etc.
- Thermometers

Per group of 3-4 students:

- Stopwatch
- Materials to make “test chambers”: Petri dishes or small disposable bowls or plates - enough for approx. 5 or 6 per group
- Roll of masking tape
- Scissors or art knife
- Paper cup
- Data Collection Chart
- Graph paper

Per student:

- Isopod Research Organizer
- Isopod Experiment Organizer
- Isopod Experiment Assessment Rubric
- Paper and pen

PREP FOR TEACHERS

Prior to teaching this lesson, you will need to:

Preview all of the video clips and Web sites used in the lesson.

Download the video clips used in the lesson to your classroom computer, or prepare to watch them using your classroom’s Internet connection.

Bookmark the Web sites used in the lesson on each computer in your classroom. Using a social bookmarking tool such as del.icio.us or diigo.com (or an online bookmarking utility such as portaportal.com) will allow you to organize all the links in a central location.

Procure live isopods (pill bugs) for the students to observe and use. Isopods are very easy to care for in the classroom, and can either be collected in the wild or ordered from a biological supply company. For more information on collecting, rearing, and keeping isopods in the classroom, see the two Isopod references mentioned in the “web sites” section.

Familiarize yourself with accepted guidelines for the safe and responsible handling of live animals in a classroom setting. The NSTA’s Responsible Use of Live Animals and Dissection in the Science Classroom (http://www.nsta.org/about/positions/animals.aspx) and the Institute for Laboratory Animal Research’s Principles and Guidelines for the Use of Animals in Precollege Education (http://dels.nas.edu/ilar_n/ilarhome/Principles_and_Guidelines.pdf) are good general resources. Also check to see if your state or district has special animal handling guidelines or requirements.

Make copies of the Isopod Research Organizer and the Isopod Experiment Organizer for each student.

INTRODUCTORY ACTIVITY

1) Tell the students that many animal behaviors can be understood as responses to changes in their environment. For example, what behavior might an animal take in response to a drop in temperature? *(Sample answers - it might seek shelter, huddle with others, eat more food to create more internal heat, move to a warmer place, or put on more clothes, in the case of humans)*. What about to a rise in temperature? *(Sample answers - it might sweat, pant, seek shelter, move to a cooler place, or wear fewer clothes and turn on a fan, in the case of humans)*.

2) Explain that each of these behaviors can be understood as a *response* to a *stimulus*, which is a detectable change - or "cue" - from the environment. Ask the students to brainstorm other changes in the environment that might serve as a stimulus for an animal to change its behavior *(Sample answers - changes in the abundance of a food source, availability of drinking water, habitat destruction or alteration, new predators moving in)*.

3) Now tell the students that among animals, *migration* is a common response to changing environmental conditions. In the video clip they are about to see, they will be introduced to four animals who migrate. Provide the students with a FOCUS FOR MEDIA INTERACTION: Ask the students to name the four migrating animals featured in the clip, and to describe their path of migration. PLAY Clip 1, "Planetary Moves," for the class (access the video segments for this lesson at the Video Segments Page, http://www.pbs.org/wnet/nature/lessons/chain-reaction/video-segments/1651/).

4) Review the focus question - what were the four species featured in the clip, and where do they migrate? *(Hooper swan - migrates north from Europe; Wildebeest - migrates across the Serengeti plains; Monarch butterfly - migrates across North America from Mexico to Canada; Sockeye salmon - migrates from river to ocean and back to river).*

5) As a follow-up question, ask the students what the stimulus was for these four animals' migration? *(The changing seasons, caused by Earth's annual journey around the sun)*. While the seasons stimulated the migration behavior, ask the students to think about what specific factors might have been causing the animals to migrate. What do they think the animals would be looking for in the new area? *(Answers may vary, but might include: looking for sources of food, warmer weather, places to breed)*.

6) Ask the students to specifically think about the monarch butterfly. In the Spring, Monarchs migrate from Mexico northward towards the United States and Canada. They then migrate back in the winter. Ask the students to predict why they think the monarchs migrate. *(Responses may vary).* Have the students write their predictions down on a scrap of paper. As they watch the next clip, provide the students with a FOCUS FOR

MEDIA INTERACTION: Test your prediction - what is the reason for the monarchs' migration? PLAY Clip 2, "Monarch Migration," for the class (access the video segments for this lesson at the Video Segments Page, http://www.pbs.org/wnet/nature/lessons/chain-reaction/video-segments/1651/).

7) Review the focus - what was the reason given for the monarchs' migration? *(Monarchs migrate southward in the winter to avoid the cold temperatures of the north).* What is the stimulus that triggers the migration from Canada to Mexico? *(The start of spring)* Point out that the monarch, as an insect, is a cold-blooded organism. One challenge all cold-blooded organisms encounter as they try to maintain internal equilibrium (homeostasis) is temperature control. Different insects adapt different strategies to avoid freezing in the winter, but the monarch's strategy is to migrate south in the winter. Migrating north in the spring and summer, on the other hand, allows them to take advantage of the blooming patterns of the monarch caterpillar's only food, the milkweed plant).

8) Tell the students that in the next clip, they will see two other animals that migrate. Provide the students with a FOCUS FOR MEDIA INTERACTION: For each animal, determine a) the reason for the migration, and b) the stimulus is that prompts the animals' migratory behavior. PLAY Clip 3, "Hungry Beasts," for the class (access the video segments for this lesson at the Video Segments Page, http://www.pbs.org/wnet/nature/lessons/chain-reaction/video-segments/1651/). When the clip is done, review the focus question *(Wildebeest - Reason for migration: searching for food - grass. Stimulus - weather dries up the grass and fires scorch it. Locust hoppers - Reason for migration: searching for food. Stimulus - population density increases to a level that there is not enough food to support the population).*

9) To round out the examples of migration, tell the students that many animals migrate to the very far north of the globe - above the Arctic Circle - for the summer. Ask the students to pair-share to think about why animals might want to migrate so far north, and have a few pairs share their thoughts with the class (accept all answers). Provide the students with a FOCUS FOR MEDIA INTERACTION: Test your predictions - determine the reasons given in the clip that animals migrate to the Arctic during the summer. Play Clip 4, "Arctic Summer," for the class (access the video segments for this lesson at the Video Segments Page, http://www.pbs.org/wnet/nature/lessons/chain-reaction/video-segments/1651/).

10) Review the focus question *(many animals migrate above the Arctic Circle because the long summer days and plentiful food are excellent conditions for raising babies)*.

11) As the activity summary, distribute exit slips with the following question: "Describe the migratory patterns of three animals you learned about in class. What stimulus triggers the migratory behavior?"

12) Collect these slips as the students are exiting the room. They can be graded and returned to the students.

LEARNING ACTIVITY 1:

1) Remind the students that migration is an example of a strategy used by animals to find environments that are suited to their needs. On a smaller scale, animals continually make choices in response to changing environmental conditions - for example by seeking warmer or colder areas, moving to areas where there is more food, etc. In this activity, students will design an experiment to test an animal's response to different environmental conditions. Explain that the students will be responsible for all aspects of their experiment - choosing a variable to test, constructing a test environment, conducting their experiment with experimental and control populations, and drawing results and conclusions from their experiments.

2) Tell the students that their experiments will use terrestrial isopods (commonly known as pill bugs, roly polies, or sowbugs) as the test subjects. Tell the students that they will first conduct preliminary observations and research on isopods to inform a hypothesis that they will test in their experiment.

3) Remind the students that the live animals to be used in these experiments must be handled in a humane fashion. Ask the students what "humane handling" might mean in the case of isopods? *(Care must be taken at every stage of the experimental process to protect the animals' well-being and protect them from harm. In particular, the experiments that the students design must not be likely to cause pain or discomfort to the animals, nor to interfere with their health and well-being. The students must also avoid any experimental procedures that might introduce nutritional deficiencies or toxicities to the animals)*.

4) If the isopod terrarium is not already visible to the class, bring it out for display. Distribute the "Isopod Research Organizer" to each student. Tell the students that they will have approximately 15 minutes to complete their Isopod Research Organizers, using a combination of observation of the live specimens and visiting Web sites to conduct further research. Pull up the two informational websites: FOSSWEB Isopods (http://lhsfoss.org/fossweb/teachers/materials/plantanimal/isopods.html), and Isopod, Pillbug, Sowbug Information (http://insected.arizona.edu/isoinfo.htm) on classroom computers. Give students approximately 15 minutes to travel between the computers and the isopod terrarium to conduct their research and to complete the student organizers.

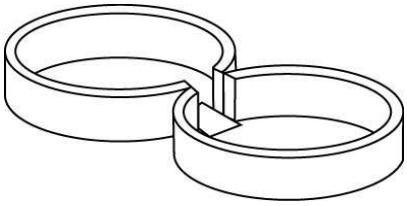
5) Review the answers to the Isopod Research Organizers as a class. Now tell the students that their research will inform hypotheses that the student groups will test by designing experiments to be conducted using the isopods.

6) Divide the students into groups of 3 or 4 students each. Assign the different student groups a variable to test (or allow them to pick their own variable - each of the variables should be tested by at least one group). The variables to be tested by the class are: light, moisture, substrate, and heat (and any other variables that you have devised for the class).

7) Direct the students to design an experiment with their chosen experimental variable or factor. They must design an experiment that will test the isopods' environmental preference in comparison with a control group.

8) In this first part of the activity, the students must: choose their materials and their experimental design, write up the research question, form a hypothesis, and write the procedure to be followed for the experiment. Later, the students will conduct the experiment according to their procedure (and will collect data and draw conclusions).

9) Distribute an "Isopod Experiment Organizer" to each student. Display all the materials available to the students to conduct their experiments. Depending on the students' ability, you may either leave it to them to design a "test chamber," or alternatively you may show them a sample test chamber (of two interconnected bowls or dishes) that you have prepared in advance, for use as a model. A possible test chamber setup is two Petri dishes, plates or bowls connected by a communicating passage:



10) Help the students complete the first page of their Isopod Experiment Organizer (through "Procedure"). The Research Question should describe the problem being addressed in the experiment, for example "Do isopods prefer moist or dry environments"? The Hypothesis should be a prediction of the outcome of the experiment based on the students' prior research. In the Materials section, students should only list those materials being used to test their variable - and it should include quantities of each material. The Procedure section should consist of numbered steps explaining the protocol of the experiment.

11) Collect the Isopod Experiment Organizers from the groups. Review them for accuracy and plausibility and return them to the students (with any suggestions necessary) prior to conducting Learning Activity 2.

LEARNING ACTIVITY 2:

1) Have the students set up their control and experimental chambers before adding any isopods to their experiment. Remind the students that they will need two sets of test chambers - one for the control group, and one for the experimental group.

2) Check the test chambers before students proceed. Remind students that all conditions except for the experimental variable must be kept as controlled as possible. Check for inconsistencies that might complicate the experiment (for example, different construction in the control vs. experimental chambers, or materials used in the

experimental setup but not in the control setup) and ask students if they can minimize the external variables.

3) Have students collect their isopods. Each student group should have the same number of specimens (approx. 20 per group will allow 10 to be used as control and 10 to be used in the experiment). When students are ready to introduce isopods into the test chambers, ask them how the isopods should best be introduced *(they should be handled gently to reduce trauma, and an equal number of animals should be placed in each chamber - not all on one side)*.

4) The second page of the Isopod Experiment Organizer can be used to collect data for the experiment. The class should decide the increments of time at which data will be collected (every minute, every two minutes, etc). Allow the students to run their experiments and collect data. If time allows, the students should run multiple trials of the experiment, using fresh specimens if available.

5) When finished with the experimental trials, have the students return their isopods to the classroom terrarium/habitat. They will analyze data and write up conclusions in the Culminating Activity.

CULMINATING ACTIVITY:

1) Give the students some time to analyze the data they collected during the isopod experiments. Remind students that charts and graphs can help interpret data. Pass out graph paper to students who request it, and remind students that they may want to average the data if it was collected over more than one trial. The students should use their prior knowledge of analysis and graphing techniques to inform the presentation of their results. If they need help thinking how best to do this, you may want to suggest some strategies or direct them to the NCES Graphing Tutorial (http://nces.ed.gov/nceskids/help/user_guide/graph/whentouse.asp), which provides a helpful summary of types of graphs and how to build them.

2) The students have now completed almost all of the elements of a scientific experiment. Ask the students if they remember the last remaining section of an experimental report, after the results have been analyzed? *(The conclusion)*. Ask the students to describe the "conclusion" of an experiment to you *(it is a narrative explanation of the results of the experiment, describing what was learned and how this experiment sheds light on the research question addressed by the proceedings)*. The conclusion of an experiment should also address any experimental error that may have occurred - it should explain what went wrong in the experiment and how it could be refined in future iterations.

3) Give the students in-class or at-home time to write their conclusion paragraphs and to assemble the complete experiment report (including the Research Question, Hypothesis, Materials, Procedure, Results, and Conclusion). Collect the reports from the students and assess them using the "Isopod Experiment Assessment Rubric." The rubrics can be returned to the students along with their graded report.

CROSS-CURRICULAR EXTENSIONS:

Psychology:

The concept of stimulus and response is widely used in human and animal behavioral modification. One early researcher into the ability for animals (including humans) to "condition" their responses was Pavlov, whose experiments with dogs are renowned. The online activity Pavlov's Dog and Conditioned Response (http://nobelprize.org/educational_games/medicine/pavlov/) from Nobelprize.org explores this concept.

Mathematics/Statistics:

Statistical analyses like chi squares and regression analysis can be used to analyze experimental data, yielding vastly more accurate conclusions. Use one or more statistical tools to analyze the results from the isopod experiment, and have students include these analyses in their conclusions (including a discussion of whether the findings are statistically significant).

COMMUNITY CONNECTIONS:

Have the students research animal migrations that affect your region. Are there measures being taken by the city, county, or region to ensure the safety and survival of migrating animals? (For example, some cities have a "lights-out" policy after 11pm during migratory bird seasons; other regions try to maintain continuous paths of undeveloped land to assist migrating birds, insects, and other animals).

NAME: _____

DATE: _____

Isopod Experiment Organizer

Research Question:

Hypothesis:

Variable being manipulated (independent variable): _____

Variable being observed for a response (dependent variable):_____

Factors that must remain constant:

Materials:

NAME: _____

DATE: _____

Procedure:

1.

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NAME: _____

DATE: _____

Data:

TRIAL #____

TIME(Min)	Experimental: # pill bugs in Chamber A (condition: _____)	Experimental: # pill bugs in Chamber B (condition: _____)	Control: # pill bugs in Chamber A	Control: # pill bugs in Chamber B
0				

Trial #____

TIME(Min)	Experimental: # pill bugs in Chamber A (condition: _____)	Experimental: # pill bugs in Chamber B (condition: _____)	Control: # pill bugs in Chamber A	Control: # pill bugs in Chamber B
0				

NATURE®

NAME: _____

DATE: _____

Isopod Research Organizer

Observe the isopods in the classroom. Use your observations and the information from the web sites below to complete this research organizer.

- http://lhsfoss.org/fossweb/teachers/materials/plantanimal/isopods.html
- http://insected.arizona.edu/isoinfo.htm

1. Sketch one of the classroom isopods:

2. How many legs do isopods have?

3. What is the meaning of the term “isopod”?

4. What are three different common names for isopods?

5. Name three other animals related to isopods:

6. Isopods are mainly (circle one):
   Producers Consumers Decomposers

7. How do pillbugs respire?

8. How do young (immature) isopods differ in appearance from adult isopods?

9. Where could you expect to find isopods in the wild?

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NAME: _____

DATE: _____

Isopod Experiment Assessment Rubric

	Criterion	**Score, from 1-5:** 1= element is missing 2= minimally satisfies 3=partially satisfies 4=mostly satisfies 5= fully satisfies
1.	Is the **research question** plausible? Does it make an inquiry that can be tested by a classroom experiment?	
2.	Is the **research question** informed by student research and observation of the subject?	
3.	Is the **hypothesis** worded as a statement?	
4.	Is the **hypothesis** a reasonable and educated guess that pertains to the research question? Does it reflect research of the subject?	
5.	Are the **independent** and **dependent variables** correctly named?	
6.	Are at least two **factors that must remain constant** correctly identified?	
7.	Is the **materials** list comprehensive of the materials used in the experiment?	
8.	Are quantities of the various **materials** specified?	
9.	Is the **procedure** written in numbered steps?	
10.	Is every step of the experiment's **procedure** listed?	
11.	Does the **procedure** clearly explain the protocol (could another conduct the experiment based on the description)?	
12.	Does the **procedure** seem scientifically plausible – will it accurately test one variable while minimizing confounding variables?	
13.	Is all the experimental **data** that was collected included in the report?	
14.	Is **data** included for control as well as experimental groups?	
15.	Is **data** included from multiple trials of the experiment conducted according to an identical procedure?	
16.	Are charts, graphs, or other visual aids used to visually present analyzed **results**?	
17.	Are the calculations correct? Do the calculations and graphs offer accurate analyses of the **results**?	
18.	Is the **conclusion** written clearly in narrative form?	
19.	Does the **conclusion** clearly indicate how the results do or do not support the hypothesis?	
20.	Does the **conclusion** address experimental error or other errors that may have occurred, and make suggestions for future research?	
	Total (Maximum 100)	

NATURE®

NAME: _____

DATE: _____

Isopod Research Organizer *ANSWER KEY*

Observe the isopods in the classroom. Use your observations and the information from the web sites below to complete this research organizer.

- http://lhsfoss.org/fossweb/teachers/materials/plantanimal/isopods.html
- http://insected.arizona.edu/isoinfo.htm

1. Sketch one of the classroom isopods:

(answers will vary)

2. How many legs do isopods have?
14, in 7 pairs

3. What are the other main anatomical features of isopods?
Head – with simple eyes and antennae; thorax - segmented into 7 segments; abdomen – with uropods at the base end.

4. What is the meaning of the term "isopod"?
Greek for "similar foot", referring to 7 pairs of legs that all have a similar purpose, rather than being specialized for grasping, etc.

5. What are three different common names for isopods?
Pillbugs, sowbugs, cressbugs, woodlice, roly-polies

6. Name three other animals related to isopods:
Shrimp, Crabs, Crayfish (students may name other known crustaceans)

7. Isopods are mainly (circle one):
Producers Consumers ***Decomposers***

8. How do pillbugs respire?
Gills - they use gill-like structures at the bases of their legs

9. How do young (immature) isopods differ in appearance from adult isopods?
They are smaller, otherwise they look identical to adult isopods.

10. Where could you expect to find isopods in the wild?
In dark, humid places with decomposing plant matter – so in leaf litter, under flower pots, under logs, etc.