Designing a Bat's Ear

In this inquiry activity, students will build and test designs for "ears" on a bat to see which design helps bats hear the best.

Objectives:

- Design construction paper "ears" that help direct sound to the ear.
- Identify variables in the designs and select a dependent variable to measure or observe in an experiment.
- Test different designs and compare results to select the most effective design.
- Present findings of an experiment to support a claim.
- Compare the design of their construction paper ears to the ears of bats.

Standards:

<table>
<tr><th>Performance Expectations</th><th>Disciplinary Core Ideas</th><th>Science & Engineering Practices</th><th>Crosscutting Concepts</th></tr>
<tr><td rowspan="3">3-LS4-3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS13: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.</td><td>LS4.B: Natural Selection
LS4.C: Adaptation
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design Solution</td><td>• Asking Questions and Defining Problems
• Planning and Carrying Out Investigations
• Analyzing and Interpreting Data
• Constructing Explanations and Designing Solutions</td><td>• Patterns
• Cause and Effect</td></tr>
<tr><td colspan="2">Common Core State Standards Connections</td><td colspan="2">Connections to the Nature of Science</td></tr>
<tr><td colspan="2">ELA/Literacy -
RI.3.1; RI.3.2; RI.3.3; W.3.1; W.3.2; SL.3.8; SL.3.4

Mathematics –
MP.2; MP.4; MP.5; 3.MD.B.3; 3.MD.8.4</td><td colspan="2">• Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
• Scientific Knowledge Assumes an Order and Consistency in Natural Systems</td></tr>
</table>

(from NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press. *www.nextgenscience.org)*

Expected timeline – 2-3 class periods
Intended audience – Grades 3-5

Note to Teachers: In the activity below, students are asked to make some choices about the research questions, the variables they measure and manipulate, and the procedures. While you could make those choices for the class, I urge you to help students learn to design an experiment by guiding them through those choices, and to give them some control of the experiment.

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Overview

Like any living thing, bats have special adaptations that help them survive. The long finger bones attached by a webbing of skin create an ideal wing. Their small bodies are lightweight, and their fur helps them conserve heat. But bats are also well known for using echolocation to find food and fly through their habitat without hitting objects. In order to detect sound accurately, bats ears have to capture sound waves and direct them to the inner ear efficiently. In this inquiry activity, you will design your own bat ears and test them to see what features seem to work best for doing this important job.

Materials:

Construction Paper
(use a 8.5" x 8.5" square sheet)
Tape
Scissors
Audio player (smart phone, tablet, etc) with volume controls
Recording of a sound – the class can select a short sound clip to use)

Inquiry Process

The Question: What features of an ear make it best at collecting sound for *(accurately locating the sound OR hearing sound from the greatest distance)?*

A. Identify variables –

What data/observations will you record as your results? (The "dependent variable")
(Suggestions: ability to locate a sound, greatest distance at which you hear the sound, loudness of the sound, etc)

What variable will you modify? (The "independent variable")

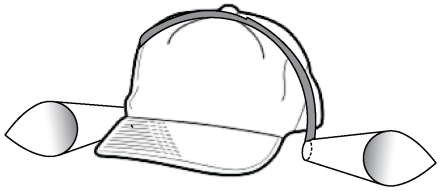
What variable will need to keep the same for each experimental trial? (The "control variables")

B. Design an Ear

In the space below or in you science journal, draw some designs for an ear – a construction paper ear you can fit over your own ear. Discuss the designs with your group or team members. Select at least two designs your team will build.
(Tip: The plan should leave the small end of the cone open and large enough for the hole to fit over your ear!)

C. Build the Ear

Now build TWO ears using each of your designs (one for each side of you head). Your teacher will provide paper, tape, scissors, and any other materials you may use.
(Tip: Attach the ears to a strip of paper that can be attached to a baseball cap to hold the ears in place.)



D. Predict/Hypothesize

PREDICTION: Once groups have built their ears, make a prediction about which design you think will work best. (Remember – refer to the variable you identified on the previous page as your results!)

HYPOTHESIS: For your hypothesis, explain *why* you think the design you chose will work best. Include the features you think make it best, and why those features might work well.

E. Design the Experiment:

The class now needs to test the predictions with an experiment. As a class, work with your teacher to decide on some important parts of the experiment.

1) What sound will you use? Pick something short, played with a device that lets you adjust the volume.

2) Where will do the test? How far away will you be from the sound? *(Options: an outdoor space, a gym or cafeteria, or the classroom)*

3) How loud will the sound need to be? (Hint: do some test runs!)

4) Will you keep the volume constant or change the volume?

5) How will measure the "dependent variable" you identified on the previous page? *(Accuracy of pointing to the sound source? Distance at which you can hear the sound? Other?)*

6) How many trials will you do?

F. Do the Experiment

It's time to do the experiment you designed on the previous page. As you work, you need to create a data table or observation chart where you can record the results! Use the space below for the tables and charts, or record those in your science journal.

G. Sharing Results

Your class needs to decide what information your group will share with the class, and how you will share it. *(Poster with graphs, written summary, oral presentation, presentation slides?)* Once you complete you experiment, share your results with the class, and discuss what you all think is the "best" design.

Analysis

Let's take the results you found and do some further analysis. You chose a "best" design based on data and observations from your experiment. Now let's compare what you found to the design of a bat's ear! Below you see some photos of ears from a variety of bats.

i) What patterns do you see in the data about ear shape and how well they helped you hear or locate the sound?

ii) How do you think the shapes of the ears you tested improved your ability to hear the sounds?

iii) How are a bat's ears similar to or different from the ears you chose as the best design in your experiment?

iv) How do you think the shape of the bats' ears might work differently from your design?

v) What advantages does a bat most need in the design of its ears: Accuracy of locating sounds or ability to hear at the greatest distance. Include an explanation of your answer.

vi) If you could design and build another ear for this experiment, what changes would you try to make to your design? What other variables could you change?