SCIENTIFIC AMERICAN FRONTIERS

TEACHING GUIDE

Activity 1: Grades 5-8

Bats and Echolocation

Bats navigate using reflected sound waves. This process, known as echolocation, allows these animals to "see" in the dark. To uncover objects, bats must first emit a series of sound pulses. These pulses travel outward and strike objects. The pulses are then reflected off the objects and return back to the bats. Detected by their large ears, the sounds are quickly analyzed by the brain's echolocation center. This analysis is so precise that the bat can locate moving fish through a critical analysis of the ripples produced at the water's surface.

This activity page will offer:

- Insight into echolocation
- Hands-on/minds-on activity in reflected sound waves
- Experience in calculating distance based upon detection of reflected sound waves

Beating A Distance

In this activity, you'll have the opportunity to approximate an object's distance by analyzing reflected sound waves. As you clap your hands, you'll send out a sound pulse. When the pulse impacts a hard surface, the sound is reflected and returns back to the sender. By analyzing the echo return time, you can calculate the distance to the reflecting surface. Here's how.

Materials

- Courtyard with high vertical wall
- Meter stick
- Wrist watch with digital display

Steps (For the set-up)

1. Work with a partner. Use a meter stick and measure a distance of 20 meters from the high wall of a courtyard.
2. Stand at this distance and clap your hands together to produce a sharp

and distinct sound. Listen carefully to detect the echo that bounces off the reflecting courtyard wall.
3. Begin clapping a steady rhythm. Distinguish the clap and its return echo. Maintain a steady rhythm of about two claps per second. Practice so your cadence becomes unerring. If necessary, base your clapping beat on the display of a digital watch.
4. Begin to increase the tempo of the clapping. Keep the rhythm steady. Increase the speed of the clapping until the claps and echoes coincide. Maintain this tempo and have your partner determine the number of claps produced in a one-second period.
5. Divide the time (1-second) by the number of claps counted to calculate the time required for the round trip travel of a single clap pulse.
6. To uncover the distance traveled by this sound wave, multiply the calculated time by the speed of sound, 344 m/s.
7. To determine the distance to the wall, divide the round trip distance by two. Compare your calculated distance with the distance you measured with your meter stick.
8. Walk about three times the distance from the reflecting wall. Repeat steps 4 through 7 to determine your new distance to the wall. After you make this mathematical calculation; use a meter stick to measure this distance. How close to the meter stick measurement was your calculated distance? What might account for any deviation in value?

Questions

1. Why is there a delay in hearing the sound of the clap and its associated echo?
2. Suppose the speed of sound was 688 m/s. How would this affect your observations?
3. Why was it important to maintain a steady beat?

Hard and Soft Targets

How might the surface properties of the echolocation target affect reflected sound waves? Would a hard target produce the same type of reflection as a softer surface? How would they be the same? How might they differ? Develop a strategy for inquire that would explore the relationship between a target's surface hardness and its echo characteristics.

Mind Play

Write a short play that takes place in the mind of bat. The characters in this play are sound and echolocation centers of the brain. Create a dialog in which these centers communicate as they try to calculate the echolocated distance to an evening meal. Try to maintain a humorous approach as you integrate real science into the conversation.

Bat Music

Surf the Internet to uncover sites that offer downloadable audio clips of bat

sounds. Listen to these sounds. Note the rhythm, melody and texture of these different clips. Then, put these sounds into a repeating loop that forms a steady rhythm track. Play the track and create your own bat-inspired melodies to the beat of the chirping rhythm.

Passive and Active Sonar

Submarines also depend upon sound for accurate navigation and "observation" of unseen objects. Like the chirping bats, subs use active sonar. They also use something called passive sonar. Use library and online references to determine the similarities and differences in these techniques. Then, present a sound-full presentation to your classmates that distinguish the two types of sonar

Web Connection

Bat Resources
http://www.cccoe.k12.ca.us/bats/resource.html
Site that offers all sorts of resources and links (some expired) on bats

"Seeing" Sounds: Echolocation by Blind Humans
http://hcs.harvard.edu/~husn/BRAIN/vol1/echo.html
An article that surveys the use of echolocation by visually impaired humans

Bat Echolocation
http://www.bats.org.uk/batinfo/batdets.htm
A variety of bat sound files in WAV and AIF formats

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Questions

1. Why is there a delay in hearing the sound of the clap and its associated echo?
   (The clap travels a short distance to your ear. The echo's travel is much longer, from your hand to the wall and back to your ear)
2. Suppose the speed of sound was 688 m/s. How would this affect your observations?
   (You'd have twice as many claps and returns in the same one-second period. The calculated distance to the wall, however, would still be the same.)
3. Why was it important to maintain a steady beat?
   (To determine the time for a round trip, you needed to overlap the sound of a clap with the echo from the previous clap. This required a steady beat from which an average time could be taken.)

CURRICULUM LINKS

Life Science :

Bat echolocation

Physical Science :

Sound waves

Speed of sound

Absorption - properties of matter

NATIONAL SCIENCE STANDARDS (Grades 5-8)

Science as Inquiry- Content Standard A

Students will conduct an investigation, gather data, and use mathematics to analyze the data.

Students will think critically about the data and formulate cause - effect relationships.

Physical Science - Content Standard B

Students will investigate sound energy and how it is transferred.

Students will examine characteristic properties of different materials.

Life Science - Content Standard C

Students will explore the structure and function of an organism.

Students will uncover one organism's adaptation for methods of obtaining food.