Bats and wave physics

Bats are fun animals to learn about, flying mammals, which are essential to tropical flower reproduction, insect control. They are also a great vehicle for teaching wave physics. Teachers have the information here to do both. The first section of the background information is about bats. The second section is about waves. Chose activities. The Bat Conservation International website has information and pictures for your class to show the different designs of nose and ear flaps that enable some bats to use echolocation..

Curriculum met: adaptations in the animal kingdom
wave physics

Equipment needed: for making waves: a small dish for small groups or a large one for a class demonstration that holds about a half inch of water, a piece of soft rope about 3-4 feet long for each pair of students, **small** embroidery hoops and lots of large latex balloons for groups or fewer balloons if adults make the oscilloscopes (probably should be made ahead of time. .

for bat adaptations in nature lesson: a picture of a bat skeleton (search engine bat skeleton diagram for one you like), black construction paper, scissors, pencils,

for adaptations in nature echolocation:3 dimensional topographic maps for each group or just one for whole class demonstration (you can make this ahead of time from Styrofoam sheets or 4 different sized Styrofoam rounds), glue,3 different colors of ribbon.

Nice if you can get them for physics, 3 D glasses and pictures, a prism for light spectrum

Optional language addition at the end of this plan.: The Saga of Smooshy to read to class and writing materials (computers, printers, pens, paper are both good) for their stories.

Make ahead directions: Echo location: Cut Styrofoam sheets about an inch thick into 3-4 squares and glue together or use 3-4 rounds glued together

Oscilloscope: for wave conclusion or bat conclusion if only doing bats. Cut a big balloon about ¾ of the way up from the lip so it pretty much lays flat. Stretch it over the inner ring of an embroidery hoop so there are no gaps around the edge and hold it all in place with outer ring of the embroidery hoop. Expect some wasted balloons.

Background information:

Familiarize yourself with the following information on bats and/or sound waves. The program directions follow the back ground information. The Saga of Smooshy is at the end

Information on bats:

If you need to get more in depth information, search Bat Conservation International. For most units the following is going to answer questions that may come up.

West Nile Virus is spread by mosquitoes, and the assumption teachers were making is that bats would reduce the mosquito population hence, the chances of getting West Nile. In fact, moths make up the bulk of the diet of the local bat population, but since we have a gypsy moth issue as well, this is good news. There is no hard evidence for bats locally being a substantial control of mosquitoes. A portion of their diet is mosquitoes, but the bulk of their diet is moths.

We want to be honest about the rabies issue. Any species that lives in colonies, like people and bats do, is prone to epidemics type illness. Bats are no more or less likely to carry rabies than any other warm blooded animal. Rabies is a viral infection of the central nervous system and is easily prevented by vaccination. The modern rabies vaccine ranks among the safest and least painful of all vaccines and provides excellent protection. Anyone who handles wild animals should obtain pre-exposure immunization, and anyone bitten or exposed to the saliva or nerve tissue of a rabies-suspect animal should immediately obtain post-exposure treatment. This treatment has been simplified and no longer requires a lengthy series of shots in the stomach as it did in the past. Dog bites remain the most frequent cause for vaccination in North America, but fatalities more often result from contact with wildlife, which is less likely to be reported and treated. You can add that colonial populations, like bats and people spread disease readily because we live in groups. Bats are no more susceptible to rabies than humans. If bats get bit by a rabid animal they can't go get shots like we can, but no mammal has any particular genetic predisposition to rabies. They are mammals, like us.

That bats get in people's hair is a myth. A bat's echo location is sensitive enough to avoid even thin wires. Bats want bugs, not hair spray, so unless a person's hair is attracting bugs, the bats are not interested.

Only two diseases have been transmitted from bats to humans in North America: histoplasmosis and rabies. Histoplasmosis is a respiratory disease caused by a fungus that grows in soil enriched by animal droppings. Ninety percent of all reported cases in humans come from the Ohio and Mississippi River valleys and adjacent areas where warm, humid conditions favor fungal growth and large flocks of birds gather each fall. The disease is rare or nonexistent in most of Canada and in the far northern and western U.S. The vast majority of cases are asymptomatic or involve no more than flu-like symptoms, though a few individuals become seriously ill, especially if exposed to large quantities of spore-laden dust. To be safe, simply avoid breathing dust in areas where there are animal droppings.

Vampire bats are very ordinary looking, weighting about one ounce and with a body the size of an adult's thumb. They are 2 3/4 inches in length and have an 8 inch wingspan.

Feeding on the blood of animals like cows, pigs, and horses, the vampire bat requires about two tablespoons of blood each day. Locating their prey is a combination of smell, sound, echo location, and possibly heat (Altringham 1996). While they do not actually suck blood from their host, they do make a small incision and lap up the blood. Since they do not chew their food, they have fewest teeth of any other bat. They generally approach their prey from the ground. "They have heat sensors on their noseleaf for locating capillary-rich areas of the skin; modified canines for fur clipping; long, sharp incisors for painlessly opening a wound; anticoagulants to prevent clotting; and a grooved tongue to help move blood rapidly to the mouth" (Altringham 1996). While the bat may consume up to 60% of its body weight in blood and it only needs the red blood cells, it will begin excreting plasma before its meal is over. With a specialized stomach and kidneys, the vampire bat rapidly removes the plasma as it may take up to twenty minutes to the bat to finish its meal (Altringham 1996). Due to length of time and the invasive nature of its feeding, it is clear the vampire bat needs its deftness and agility to be successful. "Observations of Desmodus (vampire bats) scrambling over the backs and necks of animals prior to feeding (or to avoid movements of the host animal to brush them off), and running or hopping about on the ground while feeding, illustrate the adaptive value of this effective terrestrial locomotion" (Altenbach 1996).

White nose fungus is the common name for a disease that is wiping out bat populations in the northeast and mid east states. There may be good news as European bats have survived what looks like the same disease and ours may develop resistance.

The fun stuff: Bats, like us, have teeth, and, sure, if they are grabbed, they will bite to get free. What would you do if a giant grabbed you? The tiny teeth help them grab something as small as a mosquito in flight.

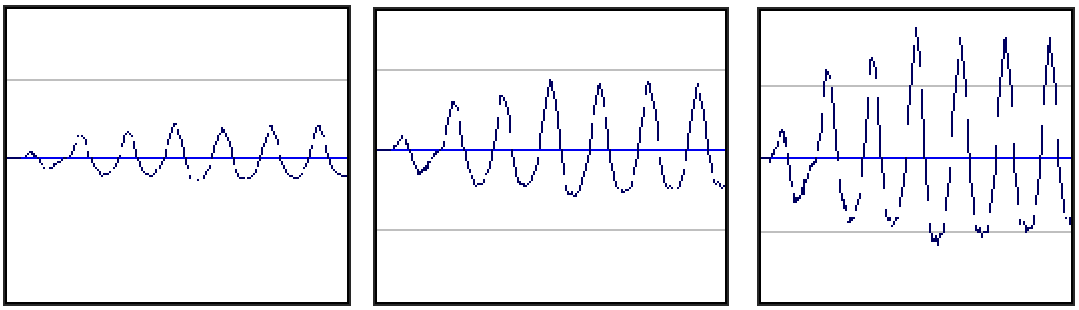
Bats are warm blooded mammals like us and may have to migrate to stay warm and find bugs in the winter. In our area they live under the bark of trees, under eaves, or shutters where they are protected from wind and rain. Some have learned to live with the traffic under bridges. If there are no caves, bats adjust.

Many bats hunt insects at dawn, dusk, and sometimes at night, when light is limited. To do this, they depend on picking up in the ear and nose flaps they have, the echo off their prey or structures. They emit a high frequency squeak and time the echo as that noise bounces off the object in front of them. They can pick up a nanosecond difference and from that determine the shape of the object in front of them. Bats are not blind, but when local bats hunt, they depend more on sound waves than light waves. Sound waves create a physical disturbance in the air. Students will be able to feel those vibrations in the balloon oscilloscope they make. Bats make and hear sounds at a higher frequency than we hear. Whales hear at lower frequencies that we can hear which is why low frequency mechanical noises are so harmful to them.

Information on sound and light waves:

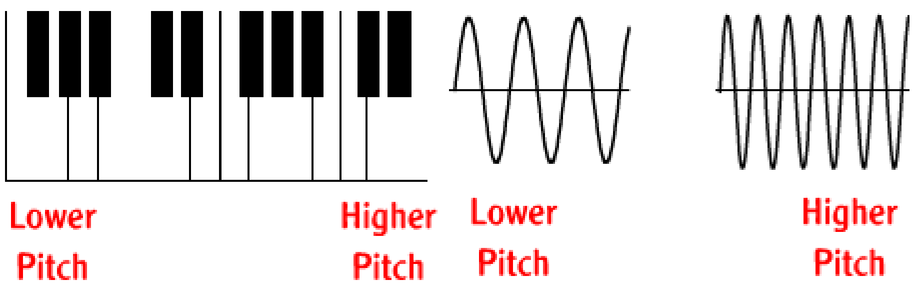
Amplitude is the height of a wave from top to bottom. If the amplitude of a wave in a roller coaster increases, what do riders feel? What if the amplitude gets small?

(If you have stretched a rubber band you can demonstrate this.) Changing the amplitude of a sound wave changes the loudness or intensity of the sound. (barely pluck the rubber band, then really pull it and let go) All three sound waves graphed below are the same guitar recording with only the amplitude changed. It may not matter depending on your students but amplitude decreases as distance from the source increases.



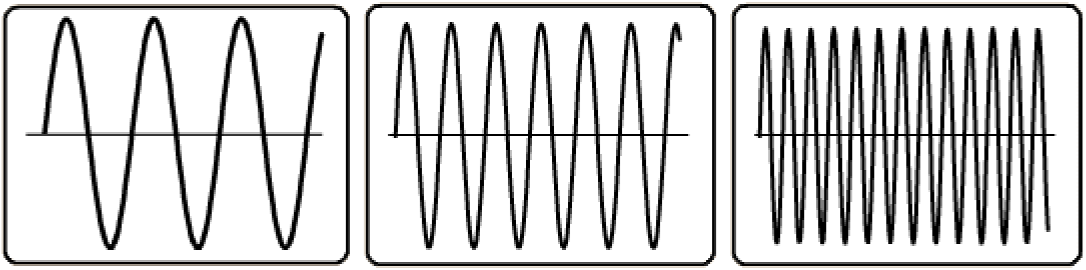
Sound: High & Low

(If you have musical instruments you can demonstrate this) Have you ever played a piano? Keys to the right side of a piano keyboard play notes that are higher than keys to the left (that play lower notes). The term pitch is used to talk about the "highness" or "lowness" of a sound. We say that the notes to the right of a piano keyboard have a higher pitch than the ones on the left.



The pitch of a sound is directly related to the frequency of the sound wave. Higher frequency means higher pitch. Lower frequency sound waves create sounds with lower pitch.

Changing the frequency of a sound wave changes the pitch of the sound. Below the frequency on the loft is low, the one on the right is high. The sounds are different notes on a piano.



From the The NASA "Why?" Files has become the NASA Science Files™. Visit us at http://scifiles.larc.nasa.gov/.

Light is a wave also. The visible part of the light is a very small part of the light energy the sun releases. Like sound, the space between wave peaks is important and varies from radio waves which are long low energy waves and gamma rays which are short high energy waves. http://csep10.phys.utk.edu/astr162/lect/light/spectrum.html

Using a prism, you can break regular white (all spectrums) light into a spectrum. We see light reflected off objects based on the reflective qualities and the pigment. If you have the 3 D glasses, you can show how different light spectrums affect what we see. Have the students look only through one color, then the other then both, and look at the pictures in white light. The blue lens of the 3D glasses blocks us from seeing red as red, and the red lens blocks us from seeing blue as blue. In white light we see both, and looking through both lenses we see a complete image as black.

Red light has a longer wave length than blue. But in nature, like the glasses, there are filters. The biggest is the ocean. The water absorbs warm colors like yellow, orange and red and letting leaving blue light. Many marine animals are red and orange or yellow so with those lights blocked they appear black and invisible. See more at http://www.whoi.edu/oceanus/viewArticle.do?id=2472 on ocean colors

There's more at http://helios.gsfc.nasa.gov/qa_gp_ls.html

To do the program

Pick the activities that meet your class needs and time constraints.

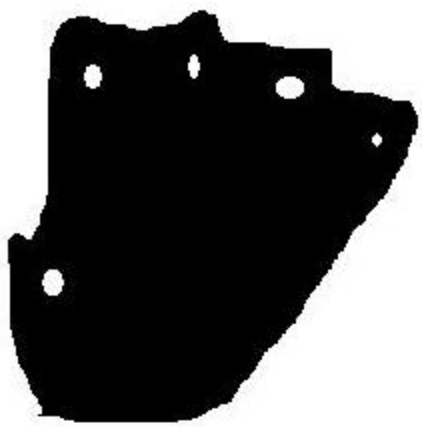
Introduction to bats: Need clip board and marker if doing the game. Time 20 minutes. You can explain from the information above about bat myths and facts. To make it a game for older students, divide the class into teams and throw out statements for each team to guess true/false to score points for the right guess.

Adaptations in animals

Uses the skeleton image, the black construction paper, pencils and scissors Time 30-40 minutes.

Bats have hands like we do, but they have really long fingers and a web of skin between the fingers and very short “arms” so their hands are wings. They have fingernails like we do, but their nails form tiny hooks. They are helped by being so small, as small as an inch. Their feet are what they hold on with, hanging upside down

Have students trace the outside of their hand on the construction paper with webbing left between the fingers. Then students cut holes for their finger tips to go through.



Have students poke just their finger tips through the holes. This is what the bat wing is like. The webbing lets them fly and their fingernails help them hold onto trees and vertical surfaces. If the students pull in their arms close to their bodies and hold their hands with the wings out, they can flap like bats.

Explain:
Bats have eyes, and can see, but since our local bats hunt at twilight, there is not enough light for them to see, just like us. This is where there is a difference between us and bats. We depend on light waves from the sun or artificial light to see where we are going and what we want. Bats depend on sound waves to hear where they are going and what they want. Our eyes are designed to focus light on the back of the eye where our nerves and brains translate this into information. The flaps and shapes of a bat’s ears and nose do the same for them with sound waves. Sound waves and light waves are similar.

Introduction to waves

Explain:
We see only a small part of the light coming from the sun. This is because our eyes are only sensitive to a small part of the light wave (a limited frequency). Light comes in waves and there are light wavelengths we can’t see. We depend on technology to see these wavelengths. For instance, there is infrared light that plants absorb for photosynthesis. There are x-rays and microwaves all coming from the sun. Our eyes are

only made to see a very small part of the light energy coming from the sun. (If you have the prism and 3 D glasses, you could do a piece on light waves here)

Sound waves are similar. Some are long, some are short, and bats hear different lengths. There are some sound wave lengths bats can hear we can't and some we hear, they may not.

Wave length has to do with distance between the top of one wave and the top of the other. Bats need fast answers, so they use "high frequency" sounds that have very little space between the top of one wave and the top of another. If the wave was stretched out (low frequency) bats could smack into a building before the echo got to them.

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Amplitude is how tall top to bottom the sound wave is. A big noise makes a tall wave. A tiny whisper makes a tiny wave. Usually, when we talk sound, we are talking amplitude, Is it loud or too loud? For bats, wave length is important. They need fast moving sounds.

Make a wave model

Have students make a light wave. Line students up side by side holding hands. At one end of the line students should be as far apart as they can be without letting go of each other's hands and waving their arms slowly up and down to simulate the long, low energy radio waves. At the other end of the line, the students should be close together and jumping up and down to simulate the short wave length, high energy gamma rays. One or two student/s in the middle is the visible light we can see. The students between the visible light and end should be moving either fast or slow depending on which side of the visible light they are on.

When the students have made their light wave, point out how much variation there is between one end and the other, and what a small part of the whole that we can see. Have each student step out of line in turn to look at the "light wave" they made.

Waves move from a transmitter (sender) to a receiver

We can't see waves of light or sound but we can make something similar with a piece of soft rope.

One person holds an end of the rope or string stable. Another person begins making waves in the string by moving it up and down. (big arm movements work best) What they are trying to do is get a smooth S shaped wave from the person creating the wave to the person receiving the wave. This only works with one receiving and one creating. Do it and then change roles. Have everyone practice, then go for illustrating vocabulary.

Have the wave creator make slow (low frequency) waves with lots of space between one wave and the next. This is low frequency, because you have to wait a long time before the next wave comes in. They are not frequent.

Now have them speed it up. This is high frequency. You don't have to wait long between waves. This is what bats use to survive. They have to find a moth while the moth is moving. A slow moving sound wave would make them late for dinner!

More on Frequency and amplitude

Put about a half inch of water in the bowl. One person at a time should tap the water with a finger to show how a disturbance, the tapping, creates waves in the water. Tapping the water fast is high frequency (lots of waves in a short time). Tapping it slowly is low frequency (a long time between waves). Tapping the water lightly making a shallow wave is low amplitude (quiet). Hitting it hard to make a high wave is high amplitude (loud) Have each student demonstrate understanding by doing one of the four that you call for. I recommend avoiding high amplitude unless you are ready for a splashed table.

We hear echoes also

Sound creates waves in the air. When they bounce off a hard object like a wall they come back toward the source. This is an echo. Bats emit high frequency sound waves and listen for the echo to come back. Can we hear an echo? Have the students face a solid wall about 10 feet away, if possible (more is better), where it is quiet. On your hand signal they should yell at the wall and get quiet as a unit. There may be a fast echo rebound if they listen fast.

Using an echo to measure distance

The echo off the wall may have come back before everyone was quiet and might have been missed/

To make the model for this section cut three or four pieces of thick sheet foam into increasingly smaller pieces or use rounds. Glue them together to make a mountain narrow at the top and wider at the bottom. You or students will use one color ribbon to stretch from a given point where the Echo, the bat, emits his sound to the bottom of the mountain. Another color ribbon will be used to measure from the same point to the middle of the mountain. The third will be used to measure from the given point to the top of the mountain. The distance (length) of the ribbon is the time it takes an echo to get back to Echo, the bat. This may work best if you make one model for the class and have students stretch the ribbons from your starting point to the different levels.

Use the model of the hill and have one student be Echo, the bat, and hold all three ribbons about mid level to the hill. Holding the ends of all three ribbons at the same height, other students stretch one to the bottom of the mountain, one to the middle, and one to the top (a different student can stretch each level). Measure the length of the ribbons from Echo to the top of the hill, then from Echo to the bottom of the hill. The shorter the length, the faster the echo comes back and the closer Echo is to the object.

Conclusion : Sound is a wave disturbance in the air

Ahead of time unless your students are adept. In short, stretch a cut large balloon over the inner ring of the embroidery hoop and use the outer ring to hold it in place to create a membrane without gaps..

Take the outer ring off the embroidery hoop, if only using one, or all of them for the groups. Using sharp scissors cut the balloons up from the opening almost 2/3 up the side, so you can flatten it out. Stretch the balloon over the inner hoop so there are no gaps along the edge, and put the outer hoop over the inner ring with the balloon to hold it in place. Tightening the outer hoop.

Explain: Our voices, like a bat's, produce waves in the air we can hear because of the way our ears pick up vibrations. We can also feel those vibrations or waves like the bat does. Holding the frame and balloon membrane very lightly between two fingers you can yell into it **without touching it to your mouth** and feel the waves/vibrations your voice makes in the air hitting the balloon. This is what a bat senses with their radar like ears and noses..

A microphone has a membrane that picks up the waves and translates them to an electrical signal. The speaker at the other end reverses that process and translates the electrical signal back to waves through membranes.

Optional Language Component

If you need a language component, the Saga can be read and students write their story of what Smooshy did when alive. We know he was a pretty well fed bat when he died.

The Saga of Smooshy:
Smooshy was a large brown bat about four inches long, found in the driveway of the park that apparently died in peace. However that didn't last long. He was sent to a taxidermist who took his insides out and stuffed him with cotton and put a string from his back so he could be suspended and look like he was flying.

Smooshy was hung in a display with dried plants and a stuffed humming bird in the park visitor center. Visitors kept shaking the display until Smooshy's string broke. He fell onto the humming bird's beak and it tore his wing. The string was not attached any more so Smooshy had to be balanced on a leaf, in a most unbat like manner.

Some workmen came and picked up the display. They did not seeing Smooshy or the humming bird and sent them and some rocks and other heavy items crashing together at the end of the display. Another person was cleaning up and pulled Smooshy out and put him in a plastic bag.

Smooshy got placed on a shelf and everyone forgot about him. A short ranger who could not see the top of the shelf put a stack of magazines on top of the bag Smooshy was in. There he was trapped between magazines for a year or more when some changes were to be made in the building.

A person began to rip out the shelves, and a ranger took the magazines down. This person picked up the bag, but thinking it was empty was going to throw it out when she heard an object slide in the bag. Opening the bag, she found Smooshy.

To keep Smooshy safe for the future he was taken to some people who make plastic display cases. They made a case with a stand for Smooshy who now had broken wings. The stand would make it look like he was flying.

Sadly, Smooshy kept falling off the stand and eventually broke one tooth. He was glued to the stand to keep him from falling off again and the cover put over him and it looked like he would be safe, if in pretty sorry shape.

Then later, the case fell off the shelf it was on and the case and Smooshy were badly damaged. Finally, Smooshy was given an appropriate resting place and the saga of Smooshy ended.

Smooshy had a rough time after he died. We're pretty sure he enjoyed himself when he was alive. Can you write a story about the good bugs and times Smooshy had while he was alive?