



Bat Ecology

Program Purpose

Through hands on games and activities students will learn how bats live and how they benefit ecosystems.

Length of Program: 1 hour

Age: Grades 3rd-12th

Maximum Number of Participants: Dependent on room size

Objectives:

After completion of all activities, students will be able to:

- Explain several bat adaptations
- Define and explain echolocation and how it is used by bats
- List the different food sources consumed by bats
- Understand White Nose Syndrome and how it is currently affecting bats
- Name several reasons why bats are beneficial and important to humans

Wisconsin Standards:

B.8.3 Explain the importance of biodiversity

B.8.8 Explain interaction among organisms or populations of organisms

F.8.7 Understand that an organism's behavior evolves through adaptation to its environment

Preparation:

Before the class arrives:

- Locate the program box in the work room
- Decide which activities to use based on age appropriateness
- Set up and review PowerPoint presentation

Materials:

Bat Skeleton

2 Blindfolds

4 Rattles

Bat skeleton diagram

Mega and Micro Bat Masks

Slinky

Bat Quiz

2 Little Brown Bats

Cotton balls and 6 scents

*Optional visual aids:**

- Powerpoint on iPads
- Power strip and extension cord

Outline:

- I. Introduction
- II. Bat quiz
- III. Bat adaptations/2 games
- IV. White Nose Syndrome
- V. Human benefits
- VI. Conclusion

Introduction:

Introduce yourself to the class and explain that we will be talking about bats. Ask the students if they are afraid of bats and possibly why. Say that by the end of the class you hope to have relieved some of their fears and helped them better understand bats.

Humans tend to find some animals naturally compelling, while others are not so appealing. For example, many of us would much rather see moose, loons, and rabbits on a jaunt in the woods than snakes, spiders, and bats. Because of the way these animals have been portrayed in myths, folklore, books, and movies, many of us are biased towards cute, furry animals, even though all species play important roles in their ecosystems. Although some of our responses to certain wildlife help protect us from danger, logic does not always guide our beliefs and behaviors. Furthermore, we tend to overlook the benefits some species offer humans and other wildlife. Many of our beliefs about animals are not based on scientific facts.

Bat Quiz:

This is a quiz of ten crazy questions intended to get the kids thinking about bats. It should be read out loud; asking for raised hands if they think the answer is true, and hands down if they think the answer is false.

Question 1: Bats are mice with wings.

False. Many people look at bats and see a flying rodent. In fact, just look at the translations of “bat” from other languages; German *fledermus* (flutter-mouse), French *chauve-souris* (bald mouse), Spanish *ratones voladores* (flying rats). Taxonomically, however, bats are more closely related to humans than mice! Fossils of bats have been dated back 55 million years; rodents didn’t evolve until about 25 million years ago. Bats and rodents are also dramatically different behaviorally. Bats usually have one baby a year and live up to age 30, while mice have large litters of young every few weeks and live only a few years.

Question 2: Bats are dirty and carry lots of diseases.

False. Bats are very clean and groom themselves daily like cats. Of course, bats are wild animals and like all wild animals *can* carry diseases such as rabies. However, less than half of 1% of bats actually have rabies. You're no more likely to contract rabies from bats than from raccoons, squirrels, or even unvaccinated dogs and cats! As with all wild animals, you run no risk of diseases from bats as long as you don't touch them.

Question 3: The world's largest bats have a wingspan of nearly 7 feet!

True. Also known as "flying foxes", these bats are members of the suborder megachiroptera, distinct from microchiroptera, the smaller, insect eating bats found in the United States and Europe. Mega bats are also called "fruit bats" although pollen and nectar are actually their preferred food source. There are a *number of different species of flying foxes* of varying sizes, but the biggest have been known to have nearly seven foot wingspans. (This is a good time to break out the tape measure and measure a student's "wingspan" and then show what seven feet would look like.) Flying foxes can be found in Asia, Australia, islands off East Africa, and on a number of islands in the Indian and Pacific Oceans.

Question 4: Vampire bats are huge bloodsucking bats that are all over the world!

False. There are lots of things wrong with this one. See if the class can name them all! For one, vampire bats are not very big at all, about the size of a human thumb. Secondly, they are not found all over the world- there are only three species of vampire bats and they are found only in the tropics from Mexico down to Argentina and Chile. Most importantly, vampire bats do not actually suck blood! They use their sharp incisors to make a cut in an animal and then lap up the blood as it falls. The bite is relatively painless and usually not even enough to wake a sleeping animal (although the bite site can become infected relatively easily). The bat's saliva even has special anticoagulants that stop the animal's blood from clotting and allows the bat to feed for longer periods of time. Another neat fact? Vampire bats find promising blood hotspots on animals through use of infrared radiation that is heat-sensitive. The only other vertebrates that can do this are boas, pythons, and pit vipers.

After feeding, the bat is too heavy to fly after having consumed two to three ounces of blood. The vampire bat will crawl away from its prey to a safe place to wait for digestion. The vampire bats kidneys are very quick and will process most of the water out of the blood within a

matter of minutes, making the bat urinate. After urinating, the bat can fly away.

Question 5: The world's smallest bat is the size of a bumblebee and weighs less than a penny.

True. The Kitti's hog-nosed bat, also known as the "bumblebee bat", is the smallest species of bat and actually the world's smallest mammal (by body size, not mass). It is found only in Thailand and Burma and is currently listed as a vulnerable species due to destruction and burning of its limited habitat. (Contrasting this tiny species with the giant flying foxes is a good way to point out to students the great range of differences among bat species even if we tend to have an image of a "stereotypical bat" in our heads.)

Question 6: All bats are carnivores.

False. Fewer than 1% of bat species are carnivores. Species that are carnivorous have been known to eat spiders, fish, birds, frogs (one species can actually differentiate between calls of frogs that are poisonous and those that are not), rodents and even occasionally smaller bats. Carnivorous bats can be found in a variety of locations from Africa to Australia to Central and South America.

Question 7: Bats fly around and get tangled in your hair.

False. Although stories and legends proliferate about this happening, it's extremely rare (likely only to happen if you disturb a roost of millions of bats). Scientists have even done studies *trying* to get bats to get tangled in wires as fine as human hairs, and the bats completely avoided them. However, bats may indeed be flying around your head at night. See if the students can guess why (it's not because they love their shampoo). Bats are merely searching for the insects hovering around your head that make for an easy meal. Bats have a highly detailed sense of direction (more about echolocation in a little bit) and are far too smart to get too close.

Question 8: Bats account for nearly 25% of all mammals.

True. The numbers of mammal and bat species differs depending on the source, but of the 4000-5000 known species of mammals, about 1,000-1,200 of them are bats. That means about a quarter of mammals can fly- not something we usually associate with the class!

Question 9: Bats are blind.

False. Many people will answer this incorrectly because they assume echolocation is the only way bats can "see". In fact, all bats can see and many species have sight that's about as good as humans. Megachiroptera (the

flying foxes we learned about earlier) don't even have echolocation- they use their big eyes to find their food and can even see in color.

Bat Adaptations:

What is an adaptation?

Ask the students if they can describe what an adaptation is. An **adaptation** is something an organism has or does to help it survive in its environment. Like all living things, bats have adaptations that help them survive in their environments. (This is also a good time to remind students how many species of bats there are and how adaptations can vary from species to species. These are general adaptations that many, not necessary all, species of bats share.)

Echolocation

Carnivorous and insectivorous bats use echolocation to locate food. This process is similar to the sonar that is used on submarines to find objects in the water, or to someone shouting in a canyon and hearing their voice return back to them. Similar to that shouting, a bat makes a high pitched sound (so high it's beyond the range of human hearing) that travels through the air in a sound wave. When these waves move outward they hit other things and bounce back. Bats have very sensitive ears and can hear these sounds bouncing back. Bats are so good at using echolocation that they can tell the difference between what is food and what is a predator or an obstruction by the shape the echo returns in. They can also tell the distance, direction, and height of these different objects based on how and when the echoes return. While searching, they will generally sound out about 10 "beeps" a second (you can have the kids try to even clap ten times in a second). When they hear something of interest, they'll speed up the beeps to get a more detailed listen. As they close in they'll speed up to 200 beeps per second and even up to 500! This adaptation helps bats find up to 3000-7000 insects a night!

The best example of how a bat uses echolocation is to get a volunteer from the audience and have them hold onto one end of a slinky. You will be holding the other end and both of you will drop to your knees to bring the slinky to the ground. Move about ten to fifteen feet apart and make a beep noise. When you make the noise send a single wave down the slinky and it will travel to the student and back to you. Every time you beep move closer and closer to the student making the beeps more rapid and more intense until you reach the student and pretend to eat them.

Game: Bat Moth

The bat moth game is intended to show students how echolocation works. Have the students make a circle and space themselves an arm length apart. Pick one student

to be the bat. Put them in the center of the circle with a blindfold on. You will then pick one to four students to be the moth. Give each moth a rattle and the game begins. Every time the bat says beep the moths must shake their rattle. The moth may move but if the bat tags them they rejoin the circle and a new moth will enter the circle. When the group gets the hang of the game you can add another bat to make things more challenging.

Mouth adaptations

Did you ever stop to think what the world would be like if all animals suddenly tried to eat just one kind of food? What if they all decided to eat just grass? The answer is simple. They soon would run out of grass and starve to death. Because animals eat a wide variety of foods, they compete less, allowing many different species of animals to live in the same habitat and maintain healthy ecosystems. Bats not only avoid competition by varying their food sources but also by hunting at night, avoiding competition with animals like birds who hunt similar prey during the day.

Most of the world's bats eat insects, and in areas with cold winters, that is all they eat. Many tropical bats eat pollen, nectar, and fruit and a few are carnivores that eat other animals, including rats and mice, small birds, frogs, lizards, or even fish. Only three out of more than 1,000 species of bats drink blood.

Each species of bat is adapted for the food it eats. Some bats specialize in eating just one or a few kinds of food, but others are generalists that eat a wide variety of foods. Most experienced bat scientists can guess what a bat eats by looking closely at its adaptations. Long, narrow wings or large tail membranes are usually adaptations for catching insects, but if the bat also has huge feet and claws, it probably eats fish. Just having large, but not overly large feet would indicate a bat that catches insects from pond surfaces. If a bat is large and has strong jaws, long canine teeth and a large tail membrane, it is probably a carnivore, adapted both to eating meat and to turning quickly while chasing prey. If it has strong jaws and long canine teeth, but has only a very small tail membrane, it is a fruit bat that does not need to chase prey, but is adapted for biting into tough-skinned fruit to squeeze the juice out. Both insect-eating and meat-eating bats always have long tails or tail membranes, but meat-eaters are the largest and have the strongest jaws. This is a good spot to take out the two bat masks from the program box and have the audience guess what types of foods each bat might eat. The mask with the big ears and small eyes is probably an insectivore relying on excellent echolocation while the bat with the small ears, big eyes, and large snout probably is a "fruit bat" that is able to easily spot and reach nectar and pollen.

Special adaptations allow bats to find and eat certain kinds of food with little or no competition from other

species. This is very successful as long as their unique food type is abundant, but such specialization is risky, because the kinds of prey, fruit, or flowers a bat eats might become scarce, leaving the bat to starve. Animals that eat a variety of foods, on the other hand, can switch types if one disappears, but they cannot compete well with specialized animals for a specific food. Most specialists live only in tropical areas where climates and food sources are the most predictable. Bats that live in northern climates like Wisconsin, where changes are frequent and unpredictable, are all insect-eaters that seldom specialize on any one insect type. In these places, it is rare to find a bat with highly specialized wings, feet, or ears.

Tail Scoop

A bat's wing membrane spreads all the way to its tail allowing for extra lift and ease of flight. The tail membrane has two other very important functions. First, it enables the bat to fly through the air and catch large amounts of bugs by making a cup with the membrane. It works like a bug net, sweeping an area to catch as many bugs as possible, and then flipping the insects towards the bat's mouth. This very effective method allows bats to catch around 600 gnat-sized insects an hour. The second important function is a baby seat. If a bat mother needs to transport her baby she will put it in the tail scoop and carry it with her.

Hanging upside down

Bats have adapted to hang upside down to avoid predators and to help conserve heat. Have the audience stand up and hang their arms at their side naturally and ask if their hands are open or closed. They're naturally open because our hand requires us to exert energy to close the hand and make a fist. A bat foot does the opposite: it requires energy exertion to open the foot, allowing the bat to hang upside down while fully asleep. This also makes it possible for bats to hang upside down from small cracks in rocks or trees and hibernate for around six months without exerting any energy.

Falling Flight

If you see a bird on the ground and startle it, there's a good chance the bird will take off and fly away. A bat on the ground cannot do the same. Bats are like jets, they need a "runway" to take off. Jets have engines that propel them forward and bats have gravity to propel them down. Bats fall a little ways to pick up speed and then take off before they hit the ground. If they are on the ground, most of them can't take off. They will crawl with their legs and the claws on their thumbs to a higher position (on a tree or building) and fall into flight. This is another great reason for hanging upside down- if a bat needs to suddenly take off all they have to do is drop into flight.

Roosting

The place a bat lives is called its roost. Bats change roost locations throughout the year as their roosting needs change. Common roosting locations include trees, caves, and human built structures (like buildings or bat boxes) when their natural habitat disappears.

Colonies

When you find a bat in a cave or some other location it is probably not alone. The bats of Bracken Cave in Texas may number up to 25 million. These bats all share this close living space for a very good reason: Heat. All of these bodies create a lot of heat and keep the cave a little warmer. As many as 200 bats can be found clinging to one square foot of rock. The nursery at Bracken Cave may have up to four million babies in it at one time. How does a bat mother find her baby? Bats have an excellent sense of smell and hearing so they can easily identify their babies by their sound and smell even in a group of four million.

Game: Where's my baby?

Many mother bats and their babies will live in a nursery colony. Born without fur, the babies pack tightly together to share body heat and stay warm. Mothers usually roost together in another part of the cave, each returning to nurse her baby several times a day. Each mother locates her own baby through recognition of its scent and call.

The class participates, but only six mothers and six babies are selected. Each baby is given a cotton ball with a scent. The mother needs to become acquainted with the smell. The baby is then assigned a call, some simple pattern of tongue clicking. Mother and baby should practice several times to ensure recognitions of scent and sound. Mothers are then blindfolded. The other students in the class are also babies but without a scent or assigned call. All babies are arranged in an open space, and the teacher places the six special babies throughout the group. All babies are stationary. Only mothers move. The goal is to have the mothers locate their own baby bats.

Hibernation

Ask the students if they've seen any bats around in Wisconsin winters and why they think this is. For an animal that relies on insects as their sole food source, a season without insects would be deadly. Bats have adapted to deal with this problem in two ways. Some species migrate south to warmer climates, like many birds. Most species enter into hibernation.

Unlike bears, whose winter denning many scientists have now taken to calling "winter sleep", bats are true hibernators. Hibernation is not just sleeping for long periods of time, it is a period when an animal has a significant metabolic and physiological shutdown. A

hibernating bat's breathing is undetectable, its body temperature drops to the temperature of the surrounding area, and its heartbeat drops from about 400 beats per minute when awake to 25 per minute while hibernating.

Two key features of bats' hibernation dramatically affect the long-term survival prospects of bat species. For one, most bat species have a very narrow range of temperatures in which they can hibernate. Very few caves are able to actually meet this range. Second, in order to get through hibernation, bats must store up fat reserves to last them through the winter. This means bats can only fly so far to get to a suitable hibernation site. Too far of a distance, and they will have used up too much of that energy to make it through the winter. With a limited amount of caves suitable for hibernation and a limited range bats can travel to get to those caves, the destruction or disturbance of even a single hibernation site can wipe out populations of bats in a wide area around it.

Bats do periodically awaken during hibernation to drink or urinate or to move to warmer or cooler spots in the cave. Each awakening, however, takes a significant amount of a bat's energy reserve, and thus the bat must limit the amount of arousals as much as possible. It is estimated that each time a bat is awakened it wastes about 10 to 30 days of stored energy. Ultimately, this means human disturbance of a hibernating bat can be disastrous- just two or three extra arousals might be enough to kill the bat.

Delayed Conception (advanced topic)

Bats live half to two thirds of their life in hibernation. Bats do not have enough time to mate and carry young to term in the short time they are awake. To over-come this problem, bats delay their conception. Unlike most animals who mate early in the spring bats mate in late fall. The female stores the sperm in her uterus and actually feeds the sperm through her cells. About two months before the end of hibernation, the sperm is released to the egg and conception occurs. This allows the female to be ready for birth at about the same time she is ready to come out of hibernation. This way, the baby is given the maximum amount of time to grow and develop into an adult before it must hibernate.

Bat Babies

To give the babies the best chance at survival, bats have adapted to be very developed when they are born. The average baby bat is about one-fourth to two-thirds the weight of its mother. This means that if your mom weighs 100 pounds, you would have weighed 33 pounds when you were born. Some bats, like the red bat, have twins!

White-Nose Syndrome:

A serious threat is currently facing bat populations in North America. White-Nose Syndrome is named after a fungus appearing on the muzzle and other body parts of hibernating bats. The fungus does not directly kill the bats, but causes them to awaken during hibernation and act in strange ways. Bats infected with WNS have been seen flying outside of their hibernacula sites and expending energy reserves they just can't afford to use, as we learned earlier. WNS has been extremely deadly, with some species of bats having a mortality rate of nearly 95%. For species that are already endangered, this is extremely worrying. Unfortunately, scientists do not yet entirely understand how the disease is spreading and have no way to cure or stop it. The disease was first discovered in New York in 2006 and as of April 2014 has spread to 25 states and 5 Canadian provinces. Unfortunately, this includes Wisconsin, where WNS was discovered in a cave in Grant County in early 2014. As of April 2014, 6 to 7 million bats have already died from WNS.

What can we do? Raising awareness of the disease is extremely important in getting funding to study the disease and find a possible cure. The US Fish & Wildlife Service has also called for a moratorium on caving in infected areas and for a thorough cleaning of any clothing or gear used while caving out of fear humans may accidentally be spreading the disease.

Human Benefits:

Are bats all that important? YES! Humans all over the world benefit from bats and their nightly habits. In this section you will expose the students to a few of the benefits.

Ask the students who likes black pepper, chewing gum, Fig Newton's, or bananas. Ask who has a grand parent or parent that has under-gone heart surgery. All of these things could not exist without bats.

- 75% of the black pepper grown in the world uses bat guano as a fertilizer.
- Gum trees, fig trees, peach trees, mango trees, avocado trees, date trees, cashew trees, and banana trees are all pollinated by bats like bees pollinate flowers. Many plants that bloom at night are ONLY pollinated by bats, as they are the only pollinators out then.
- If they have a parent or grandparent who has had heart problems they were probably given an anticoagulant made from broken down vampire bat saliva. When a vampire bat makes a cut in its dinner its saliva keeps the cut from healing by thinning the blood. This technology has been adapted to make anticoagulants for use in humans to thin blood and make it easier for the heart to pump through clogged arteries.

- Bat guano was used as an ingredient in gun powder during the civil war and is now commonly used as an excellent fertilizer by farmers and gardeners
- Dispense seeds of fruit-bearing trees
- Control insect populations

Bats are such a huge part of insect population control that a study done in 2011 placed the economic impact of bats for agriculture at \$22.9 billion a year.

Conclusion:

Wrap up the class and ask students if they like or at least respect bats a little more than they did at the start of the class. There's a good chance many of them will raise their hands. That's exactly what we want! Ask the students what they can do with this newfound respect in order to help ensure the bats we depend on so much are around for future generations. Potential answers include leaving hibernating bats alone, donating to or joining groups fighting to save habitats that bats rely on for food and shelter, keeping housecats indoors (they have been known to kill a great number of songbirds and small mammals) and maybe most easily, building a bat house for their backyard to give bats more roosting sites.

References:

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WI Standards
Environmental Education
Energy and Ecosystems
B.4.5, B.4.6, B.8.3, B.8.5, B.8.8, B.8.10

Life and Environmental Science
Organisms and their environment
F.4.4, F.4.3
Structure and Function in Living Things
F.8.2

Appendix

Additional Topics and Activities

Taxonomy:

Does anyone know what this is? It is a way for scientists to classify and organize organisms (i.e. you use folders to keep you papers in and separated from class to class). Ask if they know about vertebrates and invertebrates, if yes then they will know mammals, reptiles and such, thus being able to understand the concept of taxonomy.

Use real examples to demonstrate the progression from general to specific.

Kingdom – Amimalia [Earth]

Phyllum – Chordata (nerve chord) [North Amer]

Class – Mammalia [U.S.A]

Order – Chiroptera (hand-wing) [Wisconsin]

Family – Vespertilionidae [their town]

Genus – Myotis (mouse-eared) [WI Dells]

Species – lucifugus (little brown bat) [Upham Woods]

Food Game:

1. Divide class into groups of six or more students.
2. Distribute one complete set of Food Cards, a piece of paper and pencil to each group. Tell the group to divide the fact cards among themselves, so each student can become an expert on one of the bat eating habits.
3. Ask students to number their paper 1 – 12 down the left-hand side. Ask questions by reading the "Bat Food Clues" to the class one at a time.
4. Give each group a minute or two to discuss each given clue, and decide what type of bat it is.
5. After all clues are given and students have written their answers, go back through the clues and lead the class in discussing the answers. Bonus questions after each clue can be used to stimulate additional discussion. Each group's expert on each feeding type can be called upon to help lead discussions.

Create a Bat:

If you have extra time, a good way to get across the concept of mouth and body adaptations is to have students (working alone or in a group) to create their own bats. Have them choose a food source (encourage them to choose something kind of wacky) and then create and draw a bat that would be well adapted to finding, acquiring, and eating that food. You could also have them draw its habitat or any other elements you think are useful for getting the students to think about adaptations. Make sure they give their new bat species a name!

Bat Tour: If the group is small enough, it's night and the right season have them go view actual bats. It's a great wrap up!