RHODY CRITTER KITS

BAT CHAT

RHODE ISLAND FISH & WILDLIFE

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Learn more about Rhode Island's wildlife and our conservation programs!

Rhode Island Division of Fish and Wildlife

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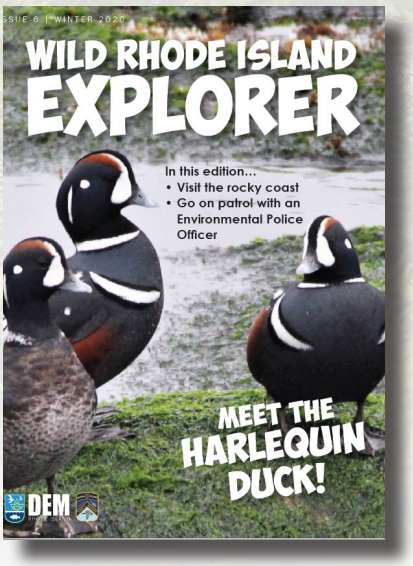
Rhode Island Department of Environmental Management



Read, learn, and explore! Sign your school up for a FREE subscription to our quarterly magazine for kids, Wild Rhode Island Explorer. For more information, visit dem.ri.gov/wildlifeoutreach.

RHODE ISLAND FISH & WILDLIFE

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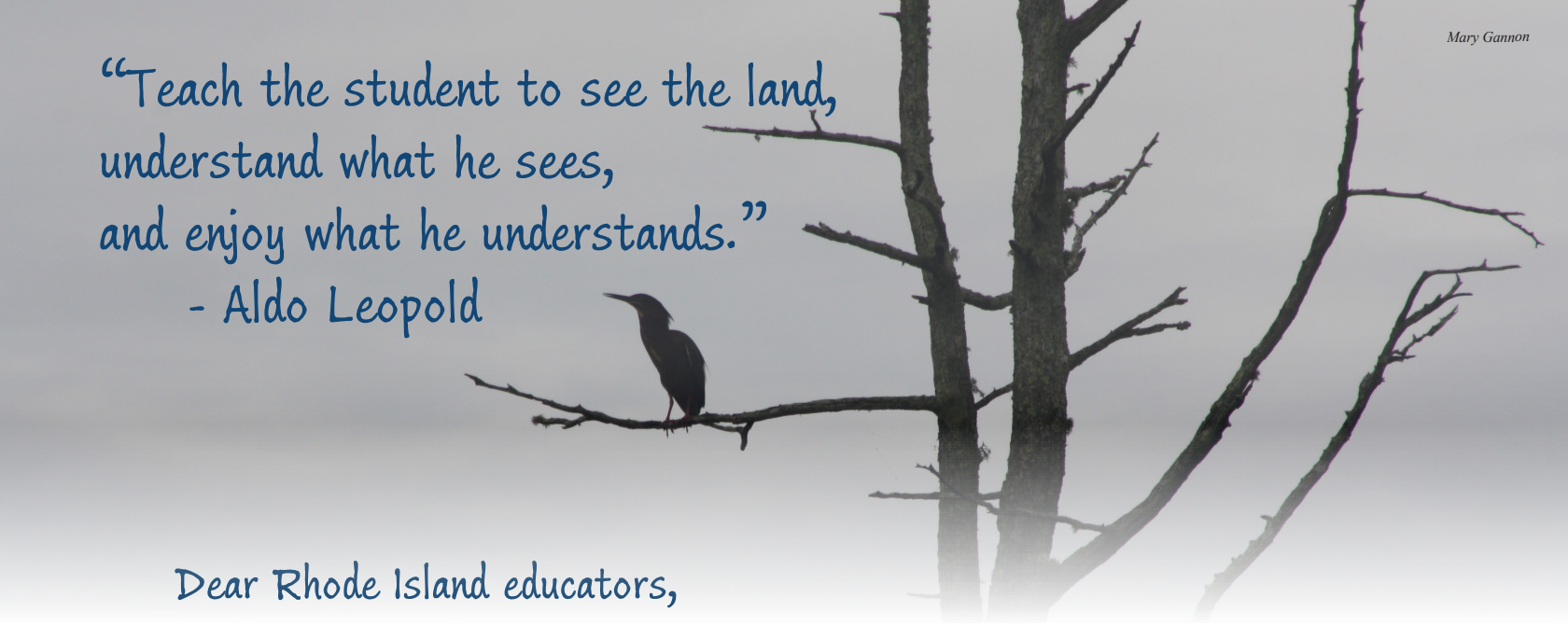
U.S. FISH & WILDLIFE SERVICE

Office of CONSERVATION INVESTMENT

Partnering to fund conservation and connect people with nature

WILDLIFE & SPORT FISH RESTORATION

Cover: Charlie Brown; Inside cover: Mike Stultz; Rhody Critter Kits logo by Nick Pires



"Teach the student to see the land,
understand what he sees,
and enjoy what he understands."
- Aldo Leopold

Dear Rhode Island educators,

Thank you so much for your participation in the RIDEM Wildlife Outreach Program, and for incorporating conservation education into your teaching practice! Through your participation in this program, you are nurturing the growth of our next generation of environmental stewards and advocating for Rhode Island's diverse and amazing wildlife. On behalf of our wild creatures, big and small, thank you!

The Wildlife Outreach Program has grown in leaps and bounds since its inception in 2017. Coordinating this program has been the most enjoyable and rewarding whirlwind I could imagine. In the wake of the COVID-19 pandemic, our team created these the Rhody Critter Kits to connect with teachers and kids, and keep Rhode Islanders engaged with our natural resources. Now more than ever, it's critical to get children outdoors, engaged with the world around them. It's been a joy to help facilitate these connections and to see this program grow! With your help, we've been able to connect thousands of students from diverse communities to our local wildlife, a feat which could not be accomplished by our tiny team alone.

These kits are not limited just to science lessons, but can be incorporated into art, reading, writing, and social studies lessons as well. We built them with room for flexibility and creativity, so you can tailor them to fit your individual class's needs. We hope the design of the kits inspires you, and encourage you and your students to have FUN with them!

When we create connections to nature in a memorable, enjoyable way, we inspire responsible stewardship and care. As educators, you are incredibly important cultivators of those connections. Every time I meet with educators who have used these kits, I am encouraged and inspired by your dedication. Thank you again!

Best wishes,
Mary Gannon

Wildlife Outreach Coordinator
Rhode Island Department of Environmental Management
Division of Fish and Wildlife

Mary.Gannon@dem.ri.gov | 401-782-3700

Gabrielle DeMeillon

Hello wonderful educators!

We couldn't be more excited to introduce you to our Rhody Critter Kit Program! While we always enjoy visiting schools in person, there are only two of us, and so many students who deserve to learn about the interesting and important wildlife that inhabit our state.

Necessity drove us to create these kits, and thank goodness it did. We strive to reach every community in Rhode Island and have now created a fun and interactive way to do so! We all rely on the resources that nature provides and are all responsible for conserving it, no matter our age. Introducing these important concepts to students today will help shape caring and responsible individuals in the future.

The Rhody Critter Kits aim to encourage students to explore the natural world around them with an open mind and observational eye. The resources provided are designed to be adapted to individual class needs, so please use them however you see fit!

Since joining the RIDEM Fish & Wildlife Outreach Team, I have had the opportunity to share our conservation work with students across the state and see their eyes grow wide with inspiration. Seeing misinformation and fear turn into awe and curiosity is one of the greatest transformations to witness. Through these kits, I hope your students are able to learn and grow in the same way. After all, knowledge is the key to growth!

Thank you for sharing in the education of future conservationists through our Rhody Critter Kit Program and we hope you have fun!

Kind regards,
Gabrielle DeMeillon

Biological Technician
Rhode Island Department of Environmental Management
Division of Fish and Wildlife

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About Us


D. Birch

The Division of Fish and Wildlife (DFW) protects, restores, and manages the freshwater and wildlife resources of the state. We share management responsibility of more than 60,000 acres of land, including 25 State Management Areas, and are responsible for thousands of species. We serve a wide and diverse segment of the public from outdoor recreationists (e.g., hunters, hikers, mountain bikers, wildlife watchers) to the general public (e.g., backyard birders, public concerned with nuisance wildlife, municipalities, legislators). In addition, we are responsible for the State's public hunter education programs and overseeing all hunting and trapping in the state. This includes setting seasons, size limits, hunting methods, and daily limits for the harvest of game species like white-tailed deer, wild turkey, waterfowl, and furbearers.


S. Petrarca

As part of a larger network of recreational opportunities in Rhode Island, hunting and fishing play an important role in connecting people with nature, supporting quality of life and family traditions, and attracting tourism. Anglers and hunters purchase around 70,000 licenses, permits, stamps, and tags each year and contribute more than $235 million to Rhode Island's economy. Revenue generated from license and permit sales support Rhode Island fish and wildlife conservation programs.

The DFW is primarily funded through the Federal Wildlife and Sport Fish Restoration Program (WSFR), which is administered through the U.S. Fish & Wildlife Service's Office of Conservation Investment. This program uses taxes placed on firearms, ammunition, and archery equipment to help fund avian and mammalian research and conservation programs, habitat acquisition, and outreach and education programs.


C. Raithel

Annual appropriations for WSFR's State Wildlife Grants (SWG) Program provide an additional, smaller, yet less restricted pot of money that can be put toward conservation of all Species of Greatest Conservation Need (SGCN) as identified in the RI Wildlife Action Plan. The list of SGCN includes game and non-game species, and also provides much needed attention to amphibians, reptiles, and invertebrates. It is our goal to responsibly manage and steward our state's wildlife resources, safeguarding them in perpetuity.

Chelsea Thompson

Bat Chat

Bats are often associated with Halloween, but in reality, they aren't all that scary! With the materials in this kit, your class will learn about bat natural history, their importance as part of a healthy ecosystem, the challenges they face, and current monitoring efforts in RI.

What's included in this kit?

- Information about Rhode Island's bats
- Resources on what to do if you encounter a bat in your home
- Sample lesson plans
- PowerPoints
- Instructions for building a bat box
- Photos and videos
- Show and tell items
- "Batty" activities from Project WILD and Project EduBat

Next Generation Science Standards

LS1A	Structure and Function
LS2A	Interdependent Relationships in Ecosystems
LS2C	Ecosystem Dynamics, Functioning, and Resilience
LS4C	Adaptation
LS4D	Biodiversity and Humans
ESS3A	Natural Resources
ESS3C	Human Impacts on Earth Systems

Are you using this kit online only?

After using these materials in your classroom, please fill out our feedback form, available on the Rhody Critter Kits page.

Are you borrowing the kit bin from the Division of Fish and Wildlife office?

Please be sure to fill out the feedback form and materials checklist (included in the bin) to ensure all items have been returned.

Kit Materials

Item	Talking Points
Little brown bat skull replica	Take a look at the bat skull when talking about bat diets. Those tiny sharp teeth are perfect for crunching up insects!
Bat puppet	A cuddly, oversized version of a big brown bat! Big brown bats are the most common species here in RI. Pair this with the "Meet the Big Brown Bat" on our Bat Chat YouTube playlist.
Counting tokens	Use these as "bugs" in the "Bat Blitz" activity.
RI bat species cards	These are the 8 species of bats that can occur in RI. Use these cards to get students familiar with our local species.
Bat photos	There are photos of a bat pollinating, a flying fox, bat pups in a maternal roost, and lists of plants that are pollinated or dispersed by bats. Illustrate your lessons with the help of these photos!
Fabric bat silhouettes	From largest to smallest, the life-sized silhouettes represent a flying fox, big brown bat, and bumblebee bat. These silhouettes help to illustrate the diversity of size in bats around the world.
Slinky & toy bugs	Use this to demonstrate how bats echolocate, showing students how "sound waves" travel along the slinky to the bug and bounce back.
Blindfold	Use for the "Bat & Moth Echolocation Game."
Bat Count (book)	This story is about a family that has bats living in their barn, information on White-Nose Syndrome, and how citizen scientists can help bats.
A Little Brown Bat Story (book)	Suitable for younger readers, this story follows a little brown bat on his-- search for a place to hibernate. This book also includes information about White-Nose Syndrome.
Bat myth cards	Bust some bat myths with these fun cards!
Mist net	This is a piece of an actual mist net used by our bat biologist to catch bats. This little fragment came from a net that was past the point of repair.
Tape measures	Use for the "How Do I Compare to a Bat?" activity.


Charles Brown

Introduction: Bats are Amazing!

In the past, bats have been cast as villains due to false myths and legends. However, bats normally pose no threat to people and are beneficial in many ways. These amazing flying mammals are the primary predator of night-flying insects, and play a crucial role in the control of agricultural pests and mosquitoes. Many bat species around the world provide **pollination** and **seed dispersal** services, especially in the rainforest. Unfortunately, many bat species are facing threats including disease, habitat loss and collisions with wind turbines. Some populations of once-common species have experienced dramatic population declines in recent years in Rhode Island and across America.

Bats are the only mammals capable of true flight, and are equipped with many unique adaptations. It is a misconception that bats are blind. In fact, most bats have excellent eyesight. Many bat species, particularly those that feed on insects, use high frequency sounds known as **echolocation** to detect prey, navigate, and communicate. Bats emit these high frequency sound pulses from their mouth or nose, which reflect off objects (such as a flying moth or beetle), and back to the bat. The bat can then pinpoint the distance, size and movement of the object. These calls are ultrasonic and beyond the range of human hearing. Each species of bat has a unique echolocation call frequency. Each year in Rhode Island, we use acoustic detection equipment to identify the species present in our state. These bat detectors translate the high pitched echolocation calls into a visible representation of the sound waves. The calls of each species make a very distinct sound wave pattern.

Read on to learn more about bats!

Bat Fun Facts

Mammalian order: Chiroptera

"Chiroptera" translates from Greek, meaning "hand-wing."

Did you know?

- There are over 1,400 bat species worldwide.
- Bats constitute about 25% of the world's total number of mammal species!
- Insect-eating bats can consume up to 4,000 insects in one night.
- There are 47 bat species in the United States.
- There are 8 bat species that can occur in Rhode Island.

Bat Species Found in Rhode Island

Eastern Red Bat

Lasiurus borealis

Resident status in RI: Summer

Wingspan: 11 to 13 inches

Weight: 0.25 to 0.46 ounces (This is about the weight of 3 to 5 pennies.)

Habitat: Red bats like to forage along field edges, farms, and forested areas with deciduous trees. During the summer, they roost in the leafy canopy.

Hibernation: Red bats migrate south for the winter. They spend the winter in hollow trees, tree bark, and leaf litter on the ground.

Big Brown Bat

Eptesicus fuscus

Resident status in RI: Year-round

Wingspan: 12 to 13 inches

Weight: 0.8 ounces (This is about the weight of 9 pennies.)

Habitat: Big brown bats are found almost everywhere in America, from deserts and forests, to farms and cities. Females form maternal colonies and roost together in buildings, barns, and bat houses during the summer.

Hibernation: Big brown bats migrate north to hibernate in caves with above-freezing temperatures. In Rhode Island, big brown bats may stay the winter and hibernate in buildings.

Information for species profiles was provided by America's Neighborhood Bats *by Merlin D. Tuttle, Adirondack Ecological Center (SUNY) and BioKIDS, an educational resource provided by the University of Michigan.*

Bat Species Found in Rhode Island

Al Hick, NYSDEC

Little Brown Bat

Myotis lucifugus

Resident status in RI: Summer

Wingspan: 8 to 10 inches

Weight: 0.18 to 0.49 ounces (This is about the weight of 2 to 5 pennies.)

Habitat: Forested areas near water, places where the bats can roost during the day, night, and hibernation

Hibernation: Little brown bats migrate north to hibernate in caves with above-freezing temperatures.

Larisa Bishop-Boros, Creative Commons

Tri-colored Bat

Perimyotis subflavus

Resident status in RI: Migrant, known to hibernate in RI; uncertain of summer residency status

Wingspan: 8 to 10 inches

Weight: 0.16 to 0.28 ounces (This is about the weight of 2 to 3 pennies.)

Habitat: Open woods near water; roosting sites include rock crevices, caves, mines, buildings, and trees

Hibernation: Tri-colored bats typically hibernate alone, or in small groups of 2-3. Most other bat species huddle together during hibernation.

Bat Species Found in Rhode Island

Northern Long-Eared Bat

Myotis septentrionalis

Resident status in RI: Summer, migrant, known to hibernate in RI

Wingspan: 9 to 10 inches

Weight: 0.21 to 0.32 ounces (This is about the weight of 2 to 3 pennies.)

Habitat: Forests

Hibernation: Northern long-eared bats typically hibernate alone, or in small groups of 2-3. Most other bat species huddle together during hibernation.

Due to severe population declines, this species was listed as Threatened under the Endangered Species Act in 2015.

Eastern Small-Footed Bat

Myotis leibii

Resident status in RI: Summer (?), migrant

Wingspan: 8 to 10 inches

Weight: 0.12 to 0.21 ounces (This is about the weight of 1 to 2 pennies.)

Habitat: Roosts include buildings, bridges, caves, mines, trees, rocky outcrops

Hibernation: Eastern small-footed bats hibernate in the coldest and driest parts of caves, which is different from other bat species.

Bat Species Found in Rhode Island

Daniel Neal, Wikimedia Commons

Hoary Bat

Lasiurus cinereus

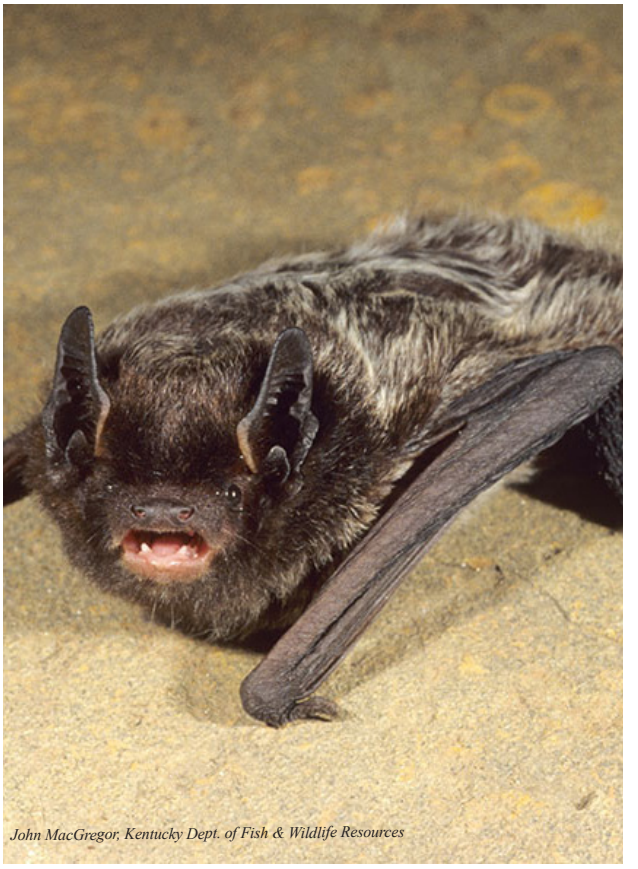
Resident status in RI: Summer (?), migrant

Wingspan: Average 16 inches

Weight: 0.70 to 1.23 ounces (This is about the weight of 7 to 13 pennies.)

Habitat: Forested areas; hoary bats are the most widespread bats in the United States. They can be found in every state (though have not yet been documented in Alaska), Canada and Central America.

Hibernation: Hoary bats migrate south for the winter, though some have been documented hibernating in northern states.



John MacGregor, Kentucky Dept. of Fish & Wildlife Resources

Silver-haired Bat

Lasionycteris noctivagans

Resident status in RI: Summer (?), migrant

Wingspan: 10 to 12 inches

Weight: 0.30 to 0.40 ounces (This is about the weight of 3 to 4 pennies.)

Habitat: Woodlands; roost sites include tree bark and tree cavities

Hibernation: Silver-haired bats migrate south for the winter, and can be found in wood piles or in crevices under rocks.


Charles Brown

Life History

Habitat and Range

In Rhode Island, cold weather and the subsequent lack of insects as a food source force bats to migrate to other areas or hibernate during the winter. **Hibernation** is a state of inactivity in which an animal reduces its metabolism and does not feed or drink for an extended period, living off stored fat reserves. The locations where bats hibernate are referred to as "**hibernacula**." Some species of bats migrate south for the winter and may remain active in warmer climates during the winter months, or hibernate only if necessary. The Eastern red bat, the silver-haired bat, and the hoary bat all migrate south from Rhode Island for the winter. Silver-haired bats are occasionally found hibernating in man-made structures in Rhode Island.

Other species, like the big brown bat, little brown bat, Eastern small-footed and Northern long-eared bat, head north for hibernation. Northern hibernacula are usually natural caves or abandoned mines with generally above-freezing temperatures and high humidity. Rhode Island does not have any natural caves or abandoned mines, so most bats that spend the summer here leave the state in late summer and fall to hibernate elsewhere. However, some individuals do remain here. The big brown bat, the most common species in our area, will frequently hibernate in buildings, and is the bat species you are most likely to encounter in Rhode Island during the winter months. If disturbed, bats can wake up during hibernation, but disturbance can cost bats valuable energy reserves critical to their survival. If the weather is very mild bats may fly during winter months to drink or feed, although this is not typical in most winters.

Food Habits

Most bat species eat insects (**insectivores**), but there are many species around the globe that feed only on fruit (**frugivore**) or nectar (**nectarivore**). There are even a few species that prey on small fish, frogs, or small rodents. There are three species of vampire bat in the tropics, which survive on vertebrate blood (**sanguinivore**). All bat species in Rhode Island and the Northeastern U.S. are strictly insectivores.

Reproduction

Bats are long-lived, which is typically not the case for most small mammals. They can live 10-20 years, with some known to live more than 30 years. Bats also have low reproductive rates. In many species, an adult female bat will only have one young per year. Female bats of some species form "nursery" or "maternal" colonies, giving birth and raising their young together. These **maternal colonies** may consist of just a few adult females or in some cases hundreds or even thousands of female bats. Male bats do not participate in caring for young bats. In most species, male bats roost alone or collect together into small "bachelor" colonies of a few individuals, often near a nursery colony. Mating takes place in the fall during **swarms**, when male and female bats congregate before entering their hibernacula. Female bats delay ovulation, and do not actually become pregnant until spring. The gestation period lasts about 2 months.

In Rhode Island there are two species of bats that frequently use man-made structures for giving birth and raising their young. The big brown bat is the most common bat species in our area, found in the most urban parts of the state to the most rural. The little brown bat was until recently also very common in our area and a frequent user of man-made structures. Female bats of both species begin to arrive at the maternity colony in late spring. They are very loyal to their maternity colony site, and will return year after year to the same location, which was probably where they were born. Maternity **roost** sites are often located in attics or loft spaces where the day and nighttime temperatures can be very high. This is especially important for the young bats during early development when it is difficult for them to regulate their body temperature, especially when their mothers leave to feed. Bats will frequently move around within the roost to find the optimal temperature conditions. Young bats, called "**pups**" are born in early summer, the first or second week of June in Rhode Island. Pups are born blind and hairless. The adult females leave the roost at dusk to feed, returning numerous times to nurse and check on their young. After 4 to 6 weeks the pups will begin attempting to fly, and by late July begin to leave the roost nightly to feed with their mothers. By late summer, the mothers and young bats gradually begin to leave the roost site entirely and move to other areas prior to migrating to their hibernacula.

Some bat species roost in trees and rarely, if ever, enter buildings unless by accident. In our area the eastern red bat, the silver-haired bat, and the hoary bat roost and have their pups high in the tree canopy, hanging from small branches. Females of these species roost alone. Other species such as the tri-colored bat and northern long-eared bat roost alone or in small groups in tree cavities or under loose bark but occasionally use man-made structures.


USFWS

White-nose Syndrome

White-nose Syndrome (WNS) is a disease that has caused rapid, dramatic declines in bat populations of some once-common species in the Eastern United States and Canada. It is caused by a fungus, *Pseudogymnoascus destructans* ("Pd") that occurs in the cold, humid environments of caves and mines where bats tend to hibernate.

How does WNS affect bats?

The fungus grows on the noses and other parts of bats and can cause the wing membrane to deteriorate. The disease affects the bats during hibernation by disrupting their metabolism, causing dehydration and loss of fat reserves. Bats arouse from hibernation apparently to search for food and water only to encounter sub-freezing temperatures, predators, and no available resources. At least 6 million bats have died in North America from this disease, but scientists believe that this is a serious underestimate, and that this number is growing. Scientists across the United States are doing research to learn how to treat and cure bats with WNS. Currently, there is no precise cure.

Where did WNS come from?

WNS was first documented in upstate New York in 2006; as of 2019 it has been confirmed in 33 states and 7 Canadian provinces. It is believed that the fungus may have been transported by humans, possibly on equipment or clothing, from caves or mines in Europe, where the fungus is now known to have originated.

Are there any human impacts?

The disease does not affect humans and the fungus does not occur in hot, dry environments such as attics. However, the loss of bats causes negative impacts on our ecosystem, which will also impact humans because of all the **ecosystem services** bats provide.

What are we doing to help in Rhode Island?

In 2016, the RI Division of Fish and Wildlife conducted sampling in the few known places where small numbers of bats hibernate in Rhode Island. The presence of the fungus was confirmed at all sites, and present on a single tri-colored bat. It was not unexpected, as WNS had been previously confirmed in all other New England states. Although large die-offs of bats have not been documented here, the finding does not bode well for the long-term viability of bat populations in the region.We continue annual monitoring of bat populations and local hibernacula.

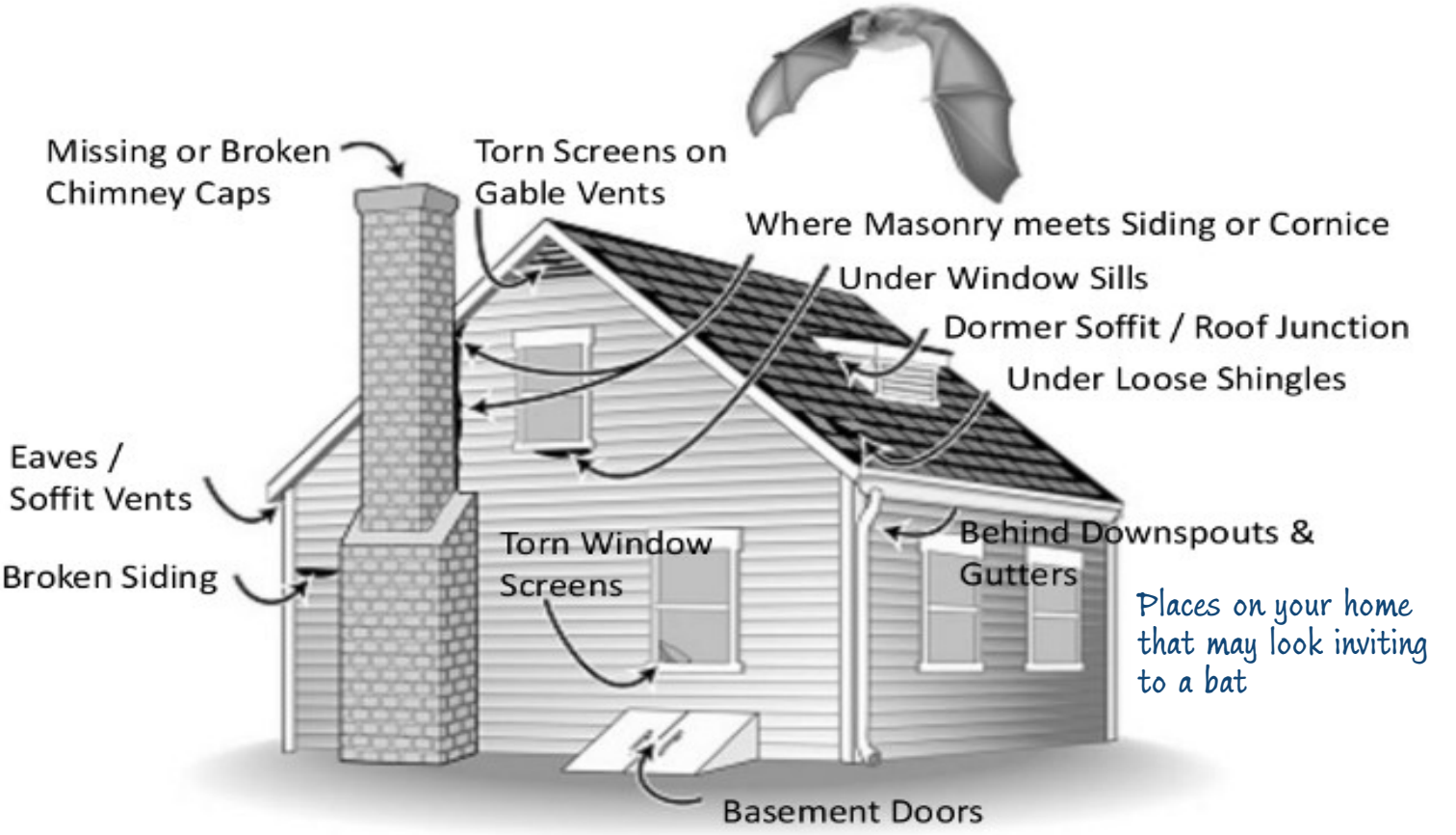
M. Gannon

Bat Conservation Work in Rhode Island

The RI Division of Fish and Wildlife uses several methods to monitor our state's bat populations year-round. In May and June, before pups are able to fly, state biologists and volunteers conduct **exit count** surveys at known maternal colony sites. At dusk, bats are counted as they exit their roost, one by one, to feed. In July, when pups are exiting the roosts with their mothers, counts are repeated. These counts give biologists an estimate of the number of adults and the number of young produced by each colony that year.

Over the course of the summer, biologists capture adult bats through the use of 24 foot tall **"mist" nets** (very thin, loose nets that catch bats as they are flying along a pathway or in a field). Once captured, each bat is weighed, measured, and inspected for signs of sexual maturity (e.g., pregnant or lactating). Lastly, each bat is given a lightweight aluminum band with a unique number registered with the United States Fish and Wildlife Service. The band is fitted to the forearm of the bat, and does not hinder flight or quality of life. This entire process takes about 5 minutes, and then the bat is released back into the wild. Recapture of banded bats provides a lot of insight into their life history. RI biologists have captured bats with wing scars from White-Nose Syndrome, which suggests that there may be some hope for bats' ability to fight the disease and survive. In RI, biologists often recapture bats at the same exact place where they were banded! Rhode Island-banded bats have also been spotted in hibernacula by biologists in Vermont. It is important to note that biologists who directly handle bats must have had a rabies vaccine, and wear leather gloves to protect themselves from the bats' sharp teeth.

Lastly, **acoustic surveys** are conducted throughout the summer and during migration periods. Bat detectors, mentioned in the introduction, are set up around the state to pinpoint potential banding sites, document which species are migrating through the state (often along the coast), and to gather general information about which bat species are present in the state. Acoustic surveys can be passive, with the detector strapped to a tree, or can be done along a driving route, with the detector strapped to a vehicle.



Living Alongside Bats: Bat-proofing Your Home

Bats are beneficial in the control of insect pests and generally do not pose a threat to humans. However, they can pose a health risk if they are handled or enter the living space of a home. There are a number of effective and humane ways to exclude bats from attics or other buildings. Sealing up entryways or using one-way devices are effective but must be done appropriately and with consideration to the time of year, otherwise these methods could lead to bats being trapped within the structure and subsequently dying. Remember, if it is between May and August and you have found a bat or evidence of bats in your home, it could be because there is a maternal colony of bats living there. On extremely hot days, bats may move down from the attic ceiling to find cooler areas to roost. Young bats attempting their first flights will often end up on the attic floor, and from there may crawl under an attic door or find other access into living quarters.

The use of poison is not a legal, humane or permanent solution and poses risks to human occupants. Poisons are toxic to humans and can remain harmful for years after they have been applied. Bats that leave the building and die on the ground outside could be handled by humans or become exposed to domestic or wild animals. Bats do not chew wood or screens, but may use openings that were created by rodents. Look for evidence of dark staining on shingles or trim boards and also look on the ground for droppings, which are black and about the size of a rice grain, and often accumulate under entry/exit points. Most bats will exit the roost within a half-hour after the first bat leaves, usually just after sunset. However, on some nights, not all of the bats will leave at the same time, and some may stay behind. Waiting outside at dusk may be the best way to determine how bats are gaining access.

Living Alongside Bats: Staying Safe

What is rabies?

Rabies is a disease caused by a virus that affects the nervous system of mammals and can be fatal without prompt medical treatment.

How is rabies transmitted?

The rabies virus is typically transmitted from an infected mammal to another mammal by a bite wound. The virus passes from the saliva of the infected mammal into the bloodstream of another, eventually moving through the central nervous system to the brain. Although rare, it is possible to become infected without being bitten, for example by having infected saliva come into direct contact with an open wound or eyes.

How common is rabies in humans?

Due to public education programs, post-exposure treatment, and vaccination programs for domestic animals, cases of humans contracting rabies in the United States are rare. Those few cases that occur are because people did not recognize the risk and did not seek medical advice.

How can you tell if an animal is rabid?

You cannot tell if a bat or other mammal has rabies just by looking at it. Rabies can only be confirmed by laboratory testing. In a given year, the RI Department of Health may test between 100 and 200 bats for rabies. The average infection rate in a given year, and over a ten year period is about 4 percent. If one bat tests positive for rabies, it does not mean all the bats in the colony also have rabies.

How to Safely Capture a Bat:

Contact a licensed professional if possible. If a licensed professional cannot be reached:

- Put on leather gloves and slowly approach the bat when it lands.
- Place a clear, see-through container over the bat.
- Slide a lid under the container to trap the bat inside.
- Securely tape the lid to the container and punch small holes in the lid so the bat can breathe.
- Call RIDOH at 401-222-2577 to make arrangements for rabies testing.

I found a bat in my home, what should I do?

Any bat that is found within a home, especially a bedroom, where there are pets, or a person who is unable to communicate, should be tested for rabies. Follow these steps to safely deal with the bat:

1. **If you are unable to capture the bat, or do not wish to attempt to capture the bat yourself, contact the RI Department of Health (401-222-2577) or the RIDEM Division of Law Enforcement (401-222-3070).** If an Environmental Police Officer is available, they may be able to provide assistance. You may be directed to one of the licensed Nuisance Wildlife Control Specialists (NWCS), who are licensed by the RIDEM to provide assistance in a number of ways to the public with respect to wild animals. They are familiar with the protocols for capture, handling, transport, and submission of specimens to the Department of Health Laboratory. A current list of Nuisance Wildlife Control Specialists is available on the RIDEM website: http://www.dem.ri.gov/programs/bnatres/fishwild/pdf/relok8rs.pdf

2. If you are bitten by a bat, wash the wound with soap and hot water.

3. **Immediately contact the RI Department of Health Rabies Hotline (401-222-2577) for instructions.** The RI Department of Health Rabies Hotline is staffed 24 hours a day, seven days a week for reports of possible exposure or for consultation. If you know or suspect a domestic animal has had contact with a bat or other wild mammal, contact the local animal control officer and a veterinarian immediately.

4. **DO NOT** release the bat, particularly if it was found in a bedroom with an unattended child, a mentally impaired person, or a pet.

5. Vaccine treatment will only be recommended if the bat tests positive for rabies. Post-exposure rabies vaccinations may be recommended when the bat is not available for testing.

What is histoplasmosis?

Histoplasmosis is a fungal disease associated with the droppings of birds and bats. Inhalation of dust containing spores can cause an infection in the lungs. Symptoms may include fever or congestion and in some cases a mild infection that may go unnoticed.

The disease is rarely fatal but people with compromised immune systems may be at risk. Do not sweep bat or bird droppings without protective clothing or an appropriate respirator. Wetting droppings before and during clean-up will reduce dust and most household disinfectants and bleach solutions will kill the spores.

Bat Vocabulary

Acoustic survey – when biologists use bat detectors to record sounds of bats to determine which bat species are in the area

Echolocation – when an animal makes a sound, and listens for how that sound bounces off an object; how bats sense the world around them

Ecosystem services – direct or indirect benefits freely provided to humans from the environment

Exit count – when biologists count how many bats are leaving a roost at sunset

Frugivore – an animal that primarily eats fruit

Hibernacula – areas where bats spend the winter to hibernate (caves, mines, buildings)

Hibernation – a state of inactivity in which an animal reduces its metabolism and does not feed or drink for an extended period, living off stored fat reserves

Histoplasmosis – a fungal disease associated with the droppings of birds and bats

Insectivore – an animal that primarily eats insects

Mammal – an animal that has fur, gives birth to live young, feeds its young with milk, and is warm blooded

Maternal colony – a place where female bats of some species gather each year to birth and raise their pups

Migration – when an animal moves from one place to another in a seasonal pattern

Mist net – a thin, light net that is hung between two tall posts to catch bats and small birds

Nectarivore – an animal that primarily eats nectar

Nocturnal – active at night

Pollination – spreading pollen from one flower to another, how plants produce fruits

Pup – a baby bat

Rabies – a disease caused by a virus that affects the nervous system of mammals

Roost – a place where bats gather to rest

Sanguinivore – an animal that primarily eats blood or other animals

Seed dispersal – the transport of a seed from its plant to another place, important for plants to continue growing in a habitat

Swarms – when male and female bats gather and mate before entering their hibernacula

Wing membrane – the skin that is stretched between a bat's fingers, allowing it to fly

White-Nose Syndrome – a fungal disease found in damp caves where bats hibernate; this disease has killed millions of bats since its discovery in 2006


Gabrielle DeMeillon

Quick Links

Bat Conservation International
Keep up to date with international bat news and conservation, and be sure to check out their Kidz Cave page!
http://www.batcon.org/
http://www.batcon.org/resources/media-education/learning

Bats Live & Project EduBat
Learn all about bats with webinars and batty activities.
https://batslive.pwnet.org/index.php

Bat Week
Become a bat hero and celebrate bats with your students!
http://batweek.org/

White-Nose Syndrome
Learn more about White-Nose Syndrome research across the country. This site includes an interactive map that shows the spread of the disease over time.
https://www.whitenosesyndrome.org/

Bat Conservation & Management
Check out this great playlist of educational videos about bats, geared towards upper elementary and middle school students.
https://batmanagement.com/pages/gallery-bat-acoustics


G. DeMeillon

Lesson 1: Bat Basics

Theme
Bats aren't as scary as you think. In fact, they're very important members of the ecosystem!

Learning Objectives
In this lesson, students will learn about the cultural connotations surrounding bats, and will bust some bat myths. Students will also learn about the basics of bat natural history, anatomy, and ecosystem services.

Corresponding Activities for this Lesson
- Bat & Moth Echolocation Game
- Bat Origami
- How Do I Compare to a Bat?
- Calculate the Value of Bats

Materials
- Lesson 1 PowerPoint
- Bat skull model
- Slinky
- Bat myth cards
- Bat silhouettes

Lesson
1. Start by asking the class how people feel about bats. As the students provide answers, write them on the board.
- Some of the answers may raise some questions. For example, many people associate bats with Halloween and vampires, which might raise the question, "Do bats want to drink your blood?" On another section of the board, write down the students' questions as they come up.
- Once the class is satisfied with the list they have created, click through the slide with the collage of pictures to review and illustrate the students' ideas. *We have provided corresponding information for each image in the notes section of the PowerPoint. You can choose to reveal some of the information to the students now or during the next parts of the lesson. You could also use the Bat Myth Cards instead.*

2. Ask students to participate in taking some guesses at the bat trivia questions and bust some bat myths. The answers to the trivia questions are included in the notes section of the PowerPoint. *Use the slinky to demonstrate how echolocation works (when busting the "blind as a bat" myth). Ask one student to be a bat and one to be a bug, standing on either end of a stretched out slinky. The bat taps the slinky, and then senses the "waves" bounce through the slinky to the bug and back!*

- Are bats blind?
- Do bats suck blood?
- How many insects can a bat eat in one night?
- Can bats carry rabies?

3. Take a look at the next slide to review some basic information about bat natural history and anatomy.

- Explain to students that bats are not rodents, but are in their own order of mammals called Chiroptera.This is a good time to show students the bat skull. Bats don't have large front teeth like rodents, but instead have lots of small, sharp teeth.
- Chiroptera means "hand-wing" in Latin, one of the languages used for scientific categorization. This makes sense, because a bat's wings are actually its hands! Take a few minutes to allow students to look at the color coded illustration of the arm and hand bones of a human compared to a bat. Ask if they can spot similarities between the two. Explain that humans and bats are both mammals, which means we have many of the same bodily structures, but have adapted to do different things. Bats use their hands to fly and scoop up insects, while humans use their hands to hold things, write, build, etc.

4. Review the next set of bat trivia questions, asking students to guess the answers. The answers to the trivia questions are included in the notes section of the PowerPoint.

- How many species of bats are there worldwide?
    - *For this question, ask students if they can figure out what the colors might mean on the map of the world. Ask if they can figure out where in the world the number of bat species is the highest.*
- How many species of bats are there in Rhode Island?
- How long can bats live?
- After reviewing the trivia questions, ask for a few volunteers to help hold up the fabric bat silhouettes to illustrate the size diversity of bats across the world. *Fabric silhouettes are provided in the hands-on kit. If you are accessing this kit online, templates for the bat silhouettes are available in the Lesson 1 section.*
    - The largest bat silhouette represents the flying fox. There are multiple species of flying foxes found across southeast Asia, East Africa, Australia, and other islands in the Indian and Pacific Oceans. The golden-crowned flying fox of the Philippines can have a wingspan up to 6 feet wide!
    - The smallest bat silhouette represents the bumblebee bat, which lives in Thailand. This is the smallest bat species in the world.
    - The medium-sized silhouette represents the big brown bat, which is the most common bat species found in Rhode Island.

5. Ask students why they might think bats are important to people and the ecosystem.

- Bats are incredibly important worldwide for insect control, pollination, and seed dispersal. Explain to students that bats provide these ecosystem services to humans for free, so it is important that we care for our bat populations. *Information about each ecosystem service can be found in the notes section of the PowerPoint.*

Myth: Bats are just mice with wings.

Mice are rodents with a set of long front teeth on the top and bottom. Bats are in a whole different order, named Chirpotera (kai-rop-ter-a), which means "hand-wing." Bats wings are actually made up of the same bones as our hands! They have a small thumb on the top and the rest are very long and are connected by a flexible membrane. They fly with a rowing motion, unlike birds, which flap. They can also use their wings to scoop insects into their mouths!

Myth: Bats are vampires!

Only vampire bats, found in the tropics (not in Rhode Island), drink blood. They make a small cut with their teeth and lap up the blood with their tongues. Most vampire bats feed from sleeping mammals or birds. Vampire bats drink about one ounce of blood per meal and they are very small. Most bat species eat fruit, insects, and flower nectar, not so scary… and they most definitely do NOT turn into vampires!

Myth: Bats are blind.

Bats can see just about as well as humans! All bats also have a "super sense" called echolocation. Echolocation calls are so high pitched that humans cannot hear them. The sound waves from the calls bounce off surrounding objects, and then back to the bat. From this, the bat is able to sense how far away an object is and use it to catch insects flying through the air!

Myth: All bats have rabies.

Bats can carry rabies, just like any mammal (even a deer can have rabies), but that doesn't mean that all bats are infected. The Rhode Island Department of Health tests about 100-200 bats per year, and over a 10-year period, only 4% of the bats tested positive for rabies. While not all bats carry rabies, we still want to be cautious, since rabies is a serious disease. If you find a bat in your home or come into contact with a bat, always let someone know and call the RIDOH Rabies hotline: 401-222-2577

Myth: Bats want to fly into your hair. Yikes!

Bats do not fly towards people with long hair on purpose. They are shy animals and are probably scared of you! They may swoop over you while foraging for insects at night, but they aren't aiming for you, they're trying to eat those pesky mosquitoes!

Myth: Bats are great at counting.

Bats aren't great at counting but… if "The Count" tried to count the number of bugs a bat ate in one night, he would get very tired! Insect-eating bats can munch between 2,000 and 6,000 bugs in one night! Ah, ah, ah!

Bonus: How many bats are in Rhode Island (Hint: It is the number on the front!)

Myth: Bats fight crime.
(Na-na-nana-na-na-nana, BATMAN!)

Bats don’t fight crime like Batman, but they are very beneficial to the environment and human populations, so they kind of help save the planet, in their own way! Bats fill lots of niches in the environment, and are important pollinators, seed dispersers, and critical insectivores. They can eat up to 1,000 insects per hour, and some eat half their body weight in one night! They eat lots of mosquitoes, moths, and beetles, so they are a natural form of pest control. Bats are especially important to farmers because they eat moths and beetles that could damage food crops.

Bat & Moth Echolocation Game

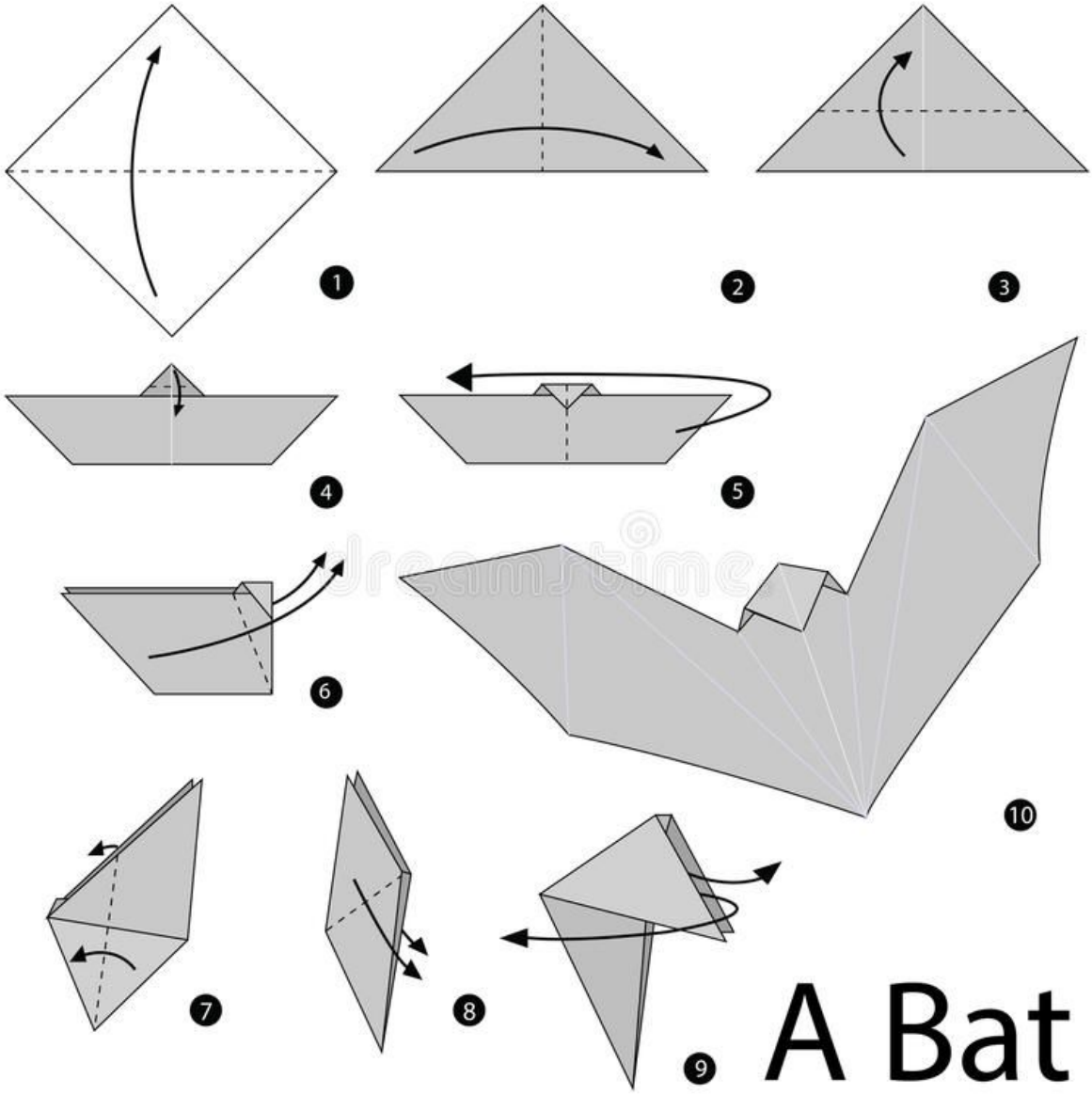
How to:

- Ask students to form a circle to form a “cave” or “forest.”
- Select a participant to be the bat and 1-2 moths, or if you have a large group choose more moths. Put a blindfold on the bat. The bat and moths must remain inside the boundaries of the forest or cave circle.
- The objective for the bat is to catch (tag) the moths by calling “Bat! Bat!” and walking around with their arms outstretched.
- The moths must reply with a loud “Moth! Moth!” immediately after the bat calls.
- If the bat touches the “forest,” the participants forming the circle should call “Tree! Tree!” When the bat has caught all the moths, choose new bats and moths for the next round.

RHODY CRITTER KITS

DEM RHODE ISLAND

RHODE ISLAND FISH & WILDLIFE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A Bat

Calculate the Value of Bats

EXPLORATION QUESTION

"Why are bats important to our economy and to our natural world?"

MATERIALS

- Pencils
- Activity Sheets A and B
- Calculator (optional)

OVERVIEW

There are many reasons for students to care about bats. They are fascinating and beautiful animals. In this activity, students will use math skills to learn about the ecological and economic impacts of bats. Students will also use communication skills to convey the importance of bats to our economy and natural world and the potential effects of White-Nose Syndrome.

VOCABULARY

Adaptation, gravity, mammal, membrane, wingspan

GROUP SIZE

Any

AGE

10-14

This activity is adapted from *Discover Bats*, a publication of Bat Conservation International. Used with permission. www.batcon.com

Background

One of the best ways to persuade people to protect bats is to explain how many insects bats can eat. Scientists have discovered that some small bats can catch up to 1,000 or more small insects in a single hour. A nursing mother bat eats the most – sometimes catching more than 4,000 insects in a night.

Little brown bats (*myotis lucifugus*) eat a wide variety of insects, including pests such as mosquitoes, moths, and beetles. If each little brown bat in your neighborhood had 500 mosquitoes in its evening meal, how many would a colony of 100 bats eat? By multiplying the average number eaten (500) times the number of bats in the colony (100), we calculate that this colony would eat 50,000 mosquitoes in an evening (500 x 100 = 50,000)!

Using a calculator and multiplying 50,000 mosquitoes times 30 days (the average number of days in a month), you can calculate that these same bats could eat 1.5 million mosquitoes in a month (50,000 x 30 = 1,500,000), not to mention the many other insects they would catch!

Do bats really eat billions of bugs?

Bracken Cave, just north of San Antonio, Texas, is home to about 20 million Mexican free-tailed bats. How many insects do you think 20 million bats can eat in a night or a month? We know that one mother Mexican free-tailed bat can eat approximately 10 grams of insects (equal to the weight of two nickels) in a night. That doesn't sound like much, but for the whole colony it actually adds up to 220 tons of insects – the approximate weight of 55 elephants!

Why do we need bats and other animals to eat insects?

Most insects are highly beneficial. Fewer than one in 100 species is a pest that attacks crops or bites people. Nevertheless, the few species that become pests are normally those that reproduce the most rapidly. Without predators, they would soon cause great damage to whole ecosystems and threaten our own survival. Bats, birds, and other predators help keep insect populations in balance. When these animals are able to do their jobs, we get to benefit from the helpful insects without being harmed too much by those that become pests.

Insect pests that attack farmers' crops can lay hundreds of eggs in just a few hours or days. This means that if a bat eats a female insect before she lays eggs, the bat is actually protecting local farmers from hundreds of this insect's offspring – the grubs and caterpillars that eat crops and gardens.

If a mosquito can lay 200 eggs that take a week to hatch and become new adults, and half (100) of those new adults are females, within just one month that one mosquito's eggs, along with those of her daughters and their daughters, could result in100,000,000 (100 x 100 x 100 x 100) new female mosquitoes (adults die soon after

laying eggs). Imagine, if none of those mosquitoes were eaten by predators like bats, how many mosquitoes would there be in two months or a year!

Now you see why we need to be kind to the animals that keep pest insects in check. These animals include bats, birds, frogs, toads, lizards, shrews, spiders, fish, and predatory insects such as ladybird beetles, wasps, and praying mantises. All these animals and insects tend to feed on different kinds of insects at different times, keeping the pest insect numbers in check. While birds and other animals eat countless millions of insects by day, bats do the same at night.

Are bats really economically important?

To assess the economic value of bats, you can research their impact on agriculture throughout the world. Bats are our most important natural predators of night-flying insects consuming mosquitoes, moths, beetles, crickets, leafhoppers, chinch bugs, and much more! Many of these insects are serious agricultural or forests pests, and others spread disease to humans or livestock. Every year bats save us billions of dollars in pest control by simply eating insects.

An article in Science, "The Economic Importance of Bats in Agriculture" estimates that bats provide between 3.7 and 22.9 billion dollars each year in pest control services in North America. The article also mentions that a single colony of 150 big brown bats in Indiana has can eat nearly 1.3 million insects that are agricultural pests each year. For these reasons, it is important to have healthy bat populations.

Recently, a unique field experiment was implemented to assess the ecological and economic effects of bats in corn agriculture (see resources list). This study found that bats not only decreased pest numbers and crop damage, but they also indirectly suppressed the presence of fungus growing on the corn. In plots of land where bats were prevented from entering, roughly 60% more corn earworm larvae were gnawing on the ears of corn. Corn is an essential crop for many farmers and is grown on more than 370 million acres worldwide. Annually, bats prevent nearly a billion dollars in pest damage to corn around the world! Even walnut growers in California are beginning to install bat houses along their orchards to attract bats that can eat coddling moths and prevent spraying of pesticides.

How has white-nose syndrome affected bats?

White-nose syndrome (WNS) is a disease that is killing bats as they hibernate in caves and mines. The disease was named for the white fuzzy fungus that appears on the muzzle, ears, and wings of affected bats. Scientist identified a previously unknown species of cold-loving fungus *Pseudogymnoascus destructans* as the cause of WNS. *P. destructans* thrives in low temperatures (40-55 F) and high humidity – conditions commonly found in caves and mines where bats hibernate.

The white powdery fungus is not always visible on affected bats. Sometimes bats with WNS simply display unusual behavior such as flying outside during the day in near-freezing weather or clustering near the entrances of hibernacula. This quickly uses up their fat reserves at a time when insects are not available for food. As a result, you may see dead or dying bats on the ground or in buildings or other structures.

First documented in New York in the winter of 2006-2007, WNS has spread rapidly across the United States and Canada. White-nose syndrome killed over 6 million bats in just six years. Bats have been found sick and dying in unprecedented numbers in and around caves and mines. In some hibernacula, 90 to 100 percent of bats have died.

Scientists around the world are urgently studying WNS. Many field and laboratory projects are underway as scientist try to discover how WNS is killing our bats, what we can do to fight it, and how to protect our surviving bats.

Get Ready -Background Activities

1. Have the students and/or the teacher read: Calculating the Value of Bats: Background Information.

2. Show your classroom the short video, "Battle for Bats: Surviving White-Nose Syndrome" (available at http://vimeo.com/76705033).

3. Lead a discussion or have student groups use a jigsaw strategy to briefly summarize each section of the background information for the entire class.

Get Set – Hand Out Materials

1. Provide each student a copy of Activity Sheets A and B.

2. If desired, provide calculators for students. Calculators will be helpful, but are not necessary.

Go! – Calculate the Value of Bats

1. Give students time to calculate their answers on the two activity pages.

2. Have students can exchange papers to check answers. Teachers and/or student volunteers can pick problems to present and explain.

3. Lead a further discussion of the implications of insect consumption by bats, which might include the following topics:
Noting the numbers of insects that bats eat and the number of eggs those insects would lay could lay is a good introduction to a discussion on the importance of predators in maintaining the balance of nature. You can also relate these numbers to the total number of people living in your town or city. Further, the answers to the problems provide a good opportunity to discuss unusually large numbers. For example, students might enjoy discussing what it would mean to be a millionaire or a billionaire.

Without a wide variety of predators such as minnows, larger insects, spiders, and bats, insects such as mosquitoes could multiply at astonishing rates and cause far more serious problems. Would it be easier to control the insects using just bats or just minnows, or might we be more successful by helping as many natural predators as possible? When we spray pesticides for mosquitoes, do we only kill mosquitoes? The answer is no. The chemicals we use to kill mosquitoes can also impact and sometimes kill their predators, such as bats.

Comparatively, the natural enemies or predators of insects often reproduce far more slowly. For example, bats typically have only one or two young per year. In the long run, the loss of bats will benefit pests such as mosquitoes and we have to use stronger insecticides which could cause greater risk to people and our environment.

Reflect – Student Assessment

1. Solve math questions correctly?

2. Persuasively describe how important bats are in balancing the number of insects in the ecosystem.

3. Accurately describe what happens if a large number of bats die.

4. Discuss the effects of White-Nose Syndrome.

Extensions – Continue the Lesson

How can you creatively and persuasively convey the importance of the quantities of insects a bat can eat in a single night, month, or whole summer season? For example, you could create interesting bat facts similar to the “55 elephants” statistics stated in the background information. You could also create a physical model or demonstration.

Research bat species that live in your region and state. Write a report or lead a discussion on specific topics. For example, “How are bats beneficial?” or “What environmental issues affect bats?”

Write a persuasive argument about how white-nose syndrome might change the magnitude of the economic and ecosystem value of bats in the eastern United States. What challenges do bat biologists face in trying to provide information to support your argument? What can students and teachers do to help bats and bat biologists?

Further Reading and Resources – Discover More

About the Value of Bats

Bats are important
http://batcon.org/index.php/why-bats/bats-are/bats-are-important

Bats are worth $1 billion to corn industry
http://www.popsci.com/bats-are-worth-1-billion-to-corn-industry

Bats can save farmers $27 billion a year!
http://www.batcon.org/index.php/resources/media-education/bci-handouts

Bats in walnut orchards: What’s the benefit?
http://westernfarmpress.com/tree-nuts/bats-walnut-orchards-what-s-benefit

BATS Magazine archive
http://www.batcon.org/resources/media-education/bats-magazine

Bats Aloft – BATS 14(3): 7-10.
Bats & Mosquitoes – BATS 28(1): 6-7
The Lives of Mexican free-tailed bats – BATS 12(3): 6-14.

Bats worth billions to agriculture: pest-control services at risk.
http://www.usgs.gov/newsroom/article.Asp?ID=2743#.U6xGwpRdUSU

Ecological and economic importance of bats (Order Chiroptera)
http://www.hindawi.com/journals/ism.biodiversity/2013.187415

Losing all these bats... what does it mean?
https://www.whitenosesyndrome.org/blog/losing-all-these-bats-what-does-it-mean

About White-Nose Syndrome

National White-Nose Syndrome (WNS) Website – http://whitenosesyndrome.org/
Learn all about WNS including the latest from the field and WNS investigations, information about partners that are involved in fighting WNS, and the most up-to-date scientific information.

Teacher Answer Page

Answers to "Calculate This" Activity Sheets

A – Calculate This! - Mexican free-tailed bats *(Tadarida brasiliensis)*

1. 4 x 10 = 40 moths
2. 20 x 500 = 10,000 eggs
3. 13 ÷ 20 = $0.65
4. 20 x $0.65 = $13
5. 4 x 454 = 1,816 moths
6. 1,816 x 400,000 = 726,400,000 moths (7.264×10^8 moths)

Bonus questions

1. 5 x 400,000 = 2,000,000 pounds (2×10^6 pounds)
2. 4,540 x 2,000,000 = 9,090,000,000 insects (9.08×10^9 insects)

Just for Fun

Your weight /2 = _____lbs

Your weight*0.5 lbs (weight of a Big Mac) = _____Big Macs Each Night!

B – Calculate This! - Little brown bats *(Myotis lucifugus lucifugus)*

1. 15 x 60 = 900 insects
2. 20 x 1,000 = 20,000 mosquitoes (2×10^4 mosquitoes)
3. 10 x 10 x 20 = 2,000 moths (2×10^3 moths)

Bonus questions

1. 200 x 4,500 = 900,000
   900,000 x 7 = 6,300,000 insects per week (6.3×10^6 insects per week)
2. 900,000 ÷ 4 = 225,000 mosquitoes (2.2×10^5 mosquitoes)
   225,000 mosquitoes in a night ÷ 2 = 112,500 female mosquitoes
   112,500 x 200 = 22,500,000 eggs! (2.25×10^7 eggs!)
3. 90% = 0.90
   0.90 x 900,000 = 810,000 insects/night that would not be caught
   0.90 x 6,300,000 = 5,670,000 (or $5.67 \times 10^{6)}$ insects/week that would not be caught
   0.90 x 225,000 = 202,500 (or $2.025 \times 10^{5)}$ mosquitoes not caught
   0.90 x 22,500,000 = 20,250,000 (or $2.025 \times 10^{7)}$ eggs laid

C – Calculate This! - Bats and Corn

1. 325 bushels X 200 acres = 65,000 bushels
2. 65,000 bushels X $3.75 = $243,750
3. 200 acres ÷ 2.47 acres X $7.88 = $638.06 per year
4. 100,000 acres ÷ 2.47 acres X $7.88 = $319,028.34 per year

Bonus Question: 370,000,000 ÷ 2.47 acres X $7.88 = $1,180,404,858.30 per year

Activity Sheet A

Calculate This!
Mexican free-tailed bats (*Tadarida brasiliensis*)

The Mexican free-tailed bats that roost in Bracken Cave in Texas eat huge number of insects during the seven months they live there. These insects include crop pests, such as corn earworm moth and the cucumber beetle, that cost American farmers billions of dollars each year. A mother Mexican free-tailed bat eats up to 10 grams of insects in a night, and one of her favorite foods is a moth that weighs one-quarter of a gram each, meaning that it takes four moths to make one gram.

1. How many of these moths does one mother Mexican free-tailed bat have to catch to equal 10 grams?

2. If half of the moths eaten are females and each female could have laid 500 eggs, how many eggs would 20 females have laid if they had not been caught?

3. If 20 female moths in one acre of crops can cause a farmer to spray pesticides to kill them, and the spraying costs $13 an acre, how much does each female moth cost the farmer?

4. At the above rate, what would a mother Mexican free-tailed bat feeding on moth pests over a farmer's crops be worth each night? Assume that half of the moths caught were females and the bats catch 20 female moths in one acre.

5. Large colonies of Mexican free-tailed bats eat many thousands of pounds of insects nightly. How many moths would it take to make one pound if four moths weigh one gram and 454 grams equal one pound?

6. The Mexican free-tailed bats at Bracken Cave in Texas eat approximately 400,000 pounds of insects nightly. How many moths that weigh one-quarter of a gram each would these bats have to catch to equal the weight of 400,000 pounds of insects?

Calculate This!
Mexican free-tailed bats (*Tadarida brasiliensis*)

Bonus questions

1. There are approximately 100 million Mexican free-tailed bats in central Texas. If the 20 million bats from Bracken Cave eat 400,000 pounds of insects in one night, how many pounds would the 100 million free-tailed bats from all of central Texas eat in one night?

2. Large numbers of moths are not always available, forcing the bats to switch to other varieties of smaller insects. On a night when they feed mostly on insects that weigh just one tenth of a gram each, it takes 4,540 of the smaller insects to make one pound. How many of these insects would the 100 million Mexican free-tailed bats of central Texas eat in one night?

Just For Fun:
Some bats eat about 1/2 their body weight in insects each night! How many Big Macs would you have to eat each night to eat the same amount of food as a bat? A Big Mac weighs about ½ of a pound.

Activity Sheet B – Calculate This!
Little brown bats (*Myotis lucifugus*)

Before White-nose Syndrome, little brown bats were among the most common bats in America and they often live near people. They eat many kinds of insects, including pest such as mosquitoes, moths, and beetles. Just one little brown bat can easily catch 1,000 mosquito-sized insects in an hour, and a nursing mother eats approximately 4,500 insects every night.

1. If a young little brown bat catches 15 insects in a minute, how many does it catch in one hour if it continues to catch insects at that rate? (60 minutes = one hour)

2. If a bat house in your neighborhood attracts 20 little brown bats and they each catch 1,000 mosquitoes in one hour, how many could all 20 bats catch in one hour?

3. If one evening, instead of eating mosquitoes, your 20 bats ate a kind of moth that weighs one-tenth of a gram (it takes 10 moths to make one gram), and each bat ate 10 grams of food, how many moths would the bats eat?

Bonus Questions

1. If you build a bat house that attracts 200 little brown bat mothers, and each bat eats approximately 4,500 insects each night, how many insects would these bats eat in one night? In one week?

2. Assume that one-quarter of the insects caught by this colony in a single night are mosquitoes. How many mosquitoes would have been caught by little brown bats? If half of the mosquitoes caught are females, and each female could have laid 200 eggs, how many eggs would the mosquitoes have laid if they had not been caught?

3. Assume that in the last six years, white-nose syndrome has killed 90% of the little brown bats in this colony. Use your answers from questions 2 and 3 to determine: How many insects would not be caught in a night and a week? How many mosquitoes would not be caught? How many eggs would those mosquitoes lay?

Activity Sheet C

Calculate This!
Bats and Corn

Worldwide, corn is grown on more than 370 million acres and is an essential crop for many farmers. Corn earworms are moths that cause major damage to corn crops by feeding on leaves and ears during their larval stage. Indirectly, corn earworm larvae also decrease the value of crops by creating avenues for infection by harmful fungi. Several species of bats commonly feed on adult corn earworms providing an important service to farmers and to those who like to eat corn. **Be sure to round to the hundredths place at the end of your calculations!**

1. An average corn crop in the United States can produce about 325 bushels of corn per acre. If you had a 200 acre farm, how many bushels of corn would you produce in a year?

2. If the average cost for a bushel of corn is currently $3.75, how money does your farm receive from your 200 acres of corn?

3. If the value of bats to corn farmers has been demonstrated at $7.88 per 2.47 acres, how much would bats provide to your farm?

4. If you had an even larger farm that produced 100,000 acres of corn, what would be the value of bats be to your farm using the rate listed above?

Bonus Question – Advanced Calculation:
4. At the above rate, how much value would bats add to farmers if there are 370 million acres of corn grow worldwide?

Common Core State Standards

Math (for main activity)
CCSS.MATH.CONTENT.6.RP.A.3
Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.
- CCSS.MATH.CONTENT.6.RP.A.3.B
Solve unit rate problems including those involving unit pricing and constant speed. For example, if it took 7 hours to mow 4 lawns, then at that rate, how many lawns could be mowed in 35 hours? At what rate were lawns being mowed?
- CCSS.MATH.CONTENT.6.RP.A.3.C
Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.
- CCSS.MATH.CONTENT.6.RP.A.3.D
Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.

Writing (for extension activity)
CCSS.ELA-Literacy.W.6.1
Write arguments to support claims with clear reasons and relevant evidence.
- CCSS.ELA-Literacy.W.6.1.a
Introduce claim(s) and organize the reasons and evidence clearly.-
- CCSS.ELA-Literacy.W.6.1.b
Support claim(s) with clear reasons and relevant evidence, using credible sources and demonstrating an understanding of the topic or text.
- CCSS.ELA-Literacy.W.6.1.c
Use words, phrases, and clauses to clarify the relationships among claim(s) and reasons.
- CCSS.ELA-Literacy.W.6.1.d
Establish and maintain a formal style.
- CCSS.ELA-Literacy.W.6.1.e
Provide a concluding statement or section that follows from the argument presented.

Next Generation Science Standards

Middle School Life Science (for extension activity)
MS-LS2-4. Ecosystems: Interactions, Energy, and Dynamics: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Common Core State Standards Connections:

ELA/Literacy -
RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-4)
RI.8.8 Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-4)
WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4)
WHST.6-8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-4)

How Do I Compare to a Bat?

EXPLORATION QUESTION

"How does the anatomy, physiology, and behavior of bats compare to humans?"

MATERIALS

- Pencils
- Copies of Student Worksheet
- "How Do I Compare to a Bat" illustration (print at least one color copy)
- Bat skeleton (optional)
- Fabric wingspans or bat models
- Metric scales (less than 30 grams)
- Tape measure
- Stopwatch or clock with second Hand
- Weight scale for humans
- Can Goods (optional)
- Calculator (optional)

OVERVIEW

Children can learn a great deal about bats and themselves by comparing various aspects of their anatomy, physiology, and behavior. In this activity, children take their own measurements and compare them to those of two bat species found in the Eastern United States, the Eastern small-footed bat and big brown bat.

VOCABULARY

Adaptation, gravity, mammal, membrane, wingspan

GROUP SIZE

Any

AGE

7 - 10

Background

Even though bats fly and people walk on the ground, bats and people are similar in many ways. That's because both people and bats are mammals. With few exceptions, all mammals give birth to live young, nurse babies with milk, and have hair. There are over 4,000 named species of mammals in the world, and bats make up a quarter of all these species. Other mammals include dogs, cats, chipmunks, raccoons, elephants, monkeys, and whales.

Bats are the only mammals that can truly fly. Other mammals such as the "flying" squirrel" and "flying" lemurs actually glide or parachute by means of a furred membrane. And, they have to climb a tree or other tall object to be able to glide. Only bats have the structural adaptations that allow for full powered flight. Flight has enabled bats to become one of the most widely distributed groups of mammals. Bats are literally found everywhere – except for the regions surrounding the North and South poles, and a few remote islands.

There are over 1,300 species of bats in the world and 47 species are found in the United States and Canada. The smallest of these bats in the Eastern United States is the Eastern small-footed bat and one of our largest is the big brown bat.

Number of fingers/Bat Wing

A bat's wing is actually a modified hand. Refer to the bat skeleton and explain how the wing bones are greatly elongated fingers. This elongation of the bones is required to support the wing membrane. Compare the bones of the wing to the fingers on a human hand. Use the "How Do I Compare to a Bat" illustration to compare the finger bones. Also point out the thumb. The thumb, usually with a sharp claw, is not attached in the wing membrane but remains free. This helps the bat crawl around on rough surfaces.

The membrane of a bat's wing is living tissue similar to the tiny flaps of skin joining the bases of our human fingers. Because the membrane of skin joins their long fingers from the bases to the tips, a bat's fingers cannot flex independently. The muscles in the arm open up the hand/wing. The structure of the wing membrane, the arrangement of the bones supporting it, and the positioning of the muscles provide the bat with the lightness and maneuverability necessary for catching insects, hovering above flowers, or quickly avoiding obstacles.

Wingspan

Bat wingspans in the Eastern United States vary from about eight inches (the Eastern small-footed bat) to almost 20 inches (Wagner's mastiff bat– found in southern Florida). The species evaluated in this activity include the Eastern small-footed bat and the big brown bat (wingspan up to 13 inches). The big brown bat was selected because it is much more widely distributed than Wagner's mastiff bat.

Height/Body Length

Students will work in pairs to measure their height (referred to as body length for bats). They will compare their height to the two bat species.

Weight

Most bats in the Eastern United States are very small. The smallest, the Eastern small-footed bat, weighs only 3.5 to 6 grams. Our largest bat, Wagner's mastiff bat, weighs up to 50 grams. The species evaluated in this activity include the Eastern small-footed bat and the big brown bat (weighs up to 25 grams).

Lifespan

The average lifespan for a human is 74 years. Among young bats, mortality is very high. If they can make it to adulthood, bats can live relatively long lives. Small bats like those found in the United States tend to live about 6-10 years.

Banding records have shown that some insectivorous bats live up to 30 to 40 years; however, this is not very common. For their size, bats are among the longest-lived animal which is important since most bats only have 1 or 2 pups a year. For comparison, most mice have a lifespan of only about two years.

Wing Beats

To support a body in the air and overcome the force of gravity, a flying animal must beat its wings very quickly to maintain altitude. Statistics for the little brown bat indicate that this bat flaps its wings about 12 times a second.

Food Consumption

Some bats can eat about half their body weight in insects each night. Scientists have discovered that many small bats can catch up to 1,000 or more small insects in a single hour.

<u>Get Ready – Set Up Stations</u>

1. Set up stations for each item to be measured or observed.

2. Provide the following items at the appropriate station:

Number of Fingers

- "How Do I Compare to a Bat" illustration
- Bat skeleton (optional)

Wingspan and Body Length/Height

- Tape measure

Weight

- Scale for students
- Gram scale
- Assorted coins
- Small bag

Lifespan

- Picture of human (with average lifespan of 74 years printed on back)
- Picture of big brown bat (with average lifespan of 6-10 years printed on back)
- Picture of a mouse (with average lifespan of 2 years printed on back)

Wing Beats

- Stop watch or clock with second hand

Food Consumption

- Can goods (optional)
- Scale for can goods (optional)

<u>Get Set -Background Activities</u>

1. Explain to students that bats and humans have many similarities. Brainstorm with the students about some of the similarities and differences between bats and humans. Include the fact that bats are mammals that give birth to live young, nurse babies with milk, and have hair.

2. Discuss some of the special adaptations unique to bats such as their ability to fly thanks to elongated finger bones and their quick wing beats.

3. Demonstrate how a bird flies by flapping your arms up and down with your elbows rigid. Ask students, "What am I?" When they respond with the correct "bird" answer, encourage further participation by asking them to form a line and fly around the room for a few minutes.

4. Bring your elbows out to the side and forward (similar to an exaggerated breast stroke). Say, "I also fly. What am I now?" Note how your arms are moving differently than a bird's wing motion. Reinforce the idea that a bat's wing encloses its very long fingers which keeps the wing spread out. Have the students repeat your arm motions and fly around the room as a bat. Encourage their enthusiasm and great leaping swoops! Compliment them on being great bats.

5. Divide students into pairs that will work together to take measurements, record times and measurements, and record other information collected at each station.

Go! - Measurement and Comparison Activity

1. Give the students the following handouts:
- Student Instruction Sheet
- Student Worksheet

2. Have the students write down their name, the kingdom that humans belong to, and what humans are usually fed as newborn babies on their Student Worksheet.

3. Have students move to each of the stations.

4. At the stations have the students work through the instructions on the Student Instruction Sheet. Each student will have a chance to measure their partner and be measured in return. Each student should keep track of their own results on their Student Worksheet.

Reflect – Student Assessment

1. Accurately measure information at each station.

2. Record all data completely.

3. Correctly calculate weight in grams.

4. Solve math questions correctly. For problem two, student's weight divided by 2 = half their weight. Multiply this by 2 to get the number of Big Macs that would need to be eaten (this turns out to be the student's weight).

5. Compare and contrast the differences between bats and humans.

Extension – Enjoy the Flight of Bats
Show your classroom the following two short videos about bat flight before or after the activity:

1. Bats in Slow Motion –Organization for Bat Conservation – (37 seconds)
http://www.youtube.com/watch?v=Ni_mS4cKPXY

2. Secrets of the Bat Wing - Science Take, The New York Times (1:30 minutes)
http://www.youtube.com/watch?v=Vq0rVBD9mDY

Ask the students to watch the bats wings. Do they see the membrane? The thumb? Encourage your students to create their own piece of art inspired by the flight of bats. The Get to Know Society hosts an online expressive arts contest for young people (19 years old or younger). Art work including fine art, photography, writing, music, and video can be entered into this free contest. The contest is geared at inspiring connections between children and nature. Get to Know also provides a fantastic tool kit of resources to help you use the expressive arts to inspire children. Be sure to go to their website at www.get-to-know.org for information on how to spark your students' inner artists. Accepted artwork will be showcased in a virtual art gallery.

Just for fun

Have students make their own bat airplanes. This fun activity is included in Project Edubat with the permission of Brian Lies. Bat airplanes can be copied for school (indoor and outdoor), library, or home use.

Suggested Resources:

Animal Diversity Web – *Eumops glaucinus*
http://animaldiversity.ummz.umich.edu/accounts/Eumops_glaucinus

Animal Diversity Web - *Myotis leibii*
http://animaldiversity.ummz.umich.edu/accounts/Myotis_leibii

Bat Conservation International – BCI Handouts
http://www.batcon.org/index.php/resources/media-education/bci-handouts

Brian Lies – The Bat Wing
http://www.brianlies.com/bat_wing.htm

BBC – Is it a Bird? Is it a Plane? Is it a flying Squirrel?
https://www.youtube.com/watch?v=UCSf5_894B4

Discovery Education – What's A Mammal?
http://www.discoveryeducation.com/teachers/free-lesson-plans/whats-a-mammal.cfm

How Do Bats Fly? – Science Take
http://www.youtube.com/watch?v=Vq0rVBD9mDY

National Wildlife Federation - Night Friends
http://batslive.pwnet.org/pdf/Night_Friends.pdf

Why Bats are More Efficient Flyers Than Birds
http://www.livescience.com/1245-bats-efficient-flyers-birds.html

Student Instruction Sheet

You will be moving from station to station to answer questions and learn how bats and humans are similar. Record all of your answers on your Student Worksheet.

Start Your Comparison

Before going to the stations, write down the kingdom that you belong to on your Student Worksheet. Also write down what you were fed as a newborn baby. Make your way to one of the available stations.

Station 1 – Write down the number of fingers that you have on one hand. Look at the bat skeleton and "How Do I Compare to a Bat" illustration and compare the bones of your hand to those of a bat.

Station 2 – Using a tape measure, have your partner measure the length of your "wingspan." You will need to stretch out your arms. Your partner will measure the distance from the fingertips on your right hand to the fingertips on your left hand. Write down the length of your wingspan and then switch places with your partner.

Station 3 – Using a tape measure, have your partner measure your height in inches. Write down your height and then switch places with your partner.

Station 4 – Step on the scale and take your own weight. You will need to convert your weight to grams. Remember that one pound equals 453.6 grams. Once you have written down your weight in pounds and grams, let your partner do the same steps. Using the gram scale, add coins to a small bag and determine how many coins equal the same weight as an Eastern small-footed bat. How many equal the same weight as a big brown bat? Are you surprised how little these bats weigh?

Station 5 – Write down what you think is the average lifespan of a human. Pick up the photo of the person and look at the back to see if you answered correctly. Record the correct answer and compare this to the average lifespan of a bat. Also look on the back of the photo of the mouse. How long do they live on average?

Station 6 -To determine wing beats per minute, you will have to flap your arms like a bat for thirty seconds. Be sure to count the number of times you flap out loud so that you don't lose track. Your partner will tell you when to begin and when to stop using a stopwatch or clock. You will need to multiply the number of wing flaps times two to find the rate per minute. Remember to record your answer. How does your rate compare to the bats'? Why do they need to move their wings so quickly?

Station 7 - Bats eat an incredible amount of insects each night. In fact, they can eat about half of their weight in insects each evening. How many Big Macs would you have to eat each night to eat the same amount of food as a bat? Hint, a Big Mac weighs about 0.5 lbs. Show your work and be sure to write down your final answer. If available, add can goods to the scale until you have added enough food to equal half your body weight. Think about trying to eat that amount of food in a single evening.

How Do I Compare to a Bat? – Student Worksheet

Name: _____

Characteristic/Measurement	Student	Eastern Small-Footed Bat	Big Brown Bat
Kingdom		Mammal	Mammal
Drink as a Baby		Milk	Milk
Number of Fingers		4 fingers and 1 thumb	4 fingers and 1 thumb
Wingspan		8.2- 10.2 inches	up to 13 inches
Height/Body Length		2.9 to 3.4 inches	4 to 5 inches
Weight		3.5 to 6 grams	up to 25 grams
Average Lifespan		6-10 years	6-10 years
Wings Beats Per Minute		About 720*	About 720*

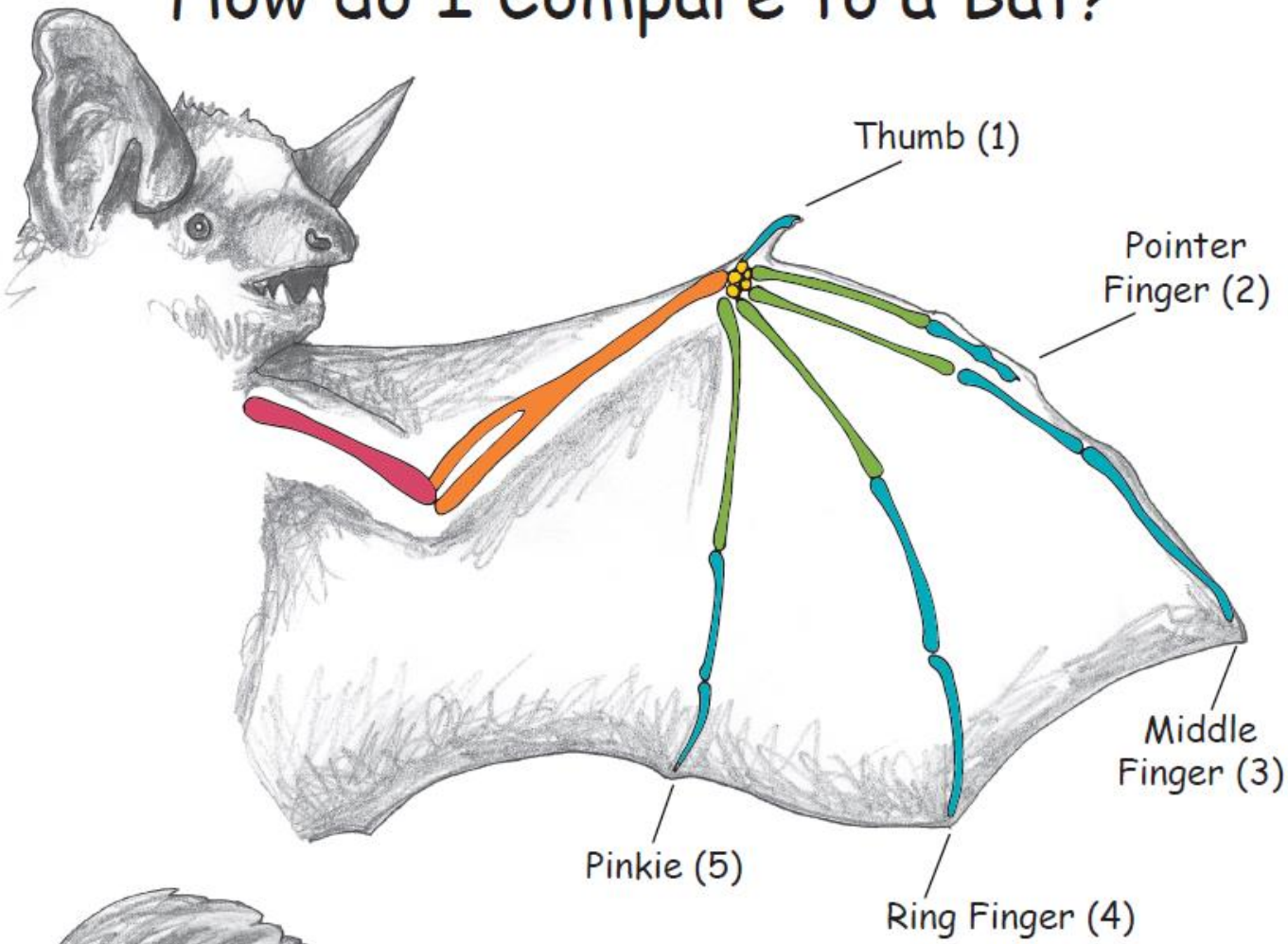
*Statistics for the little brown bat

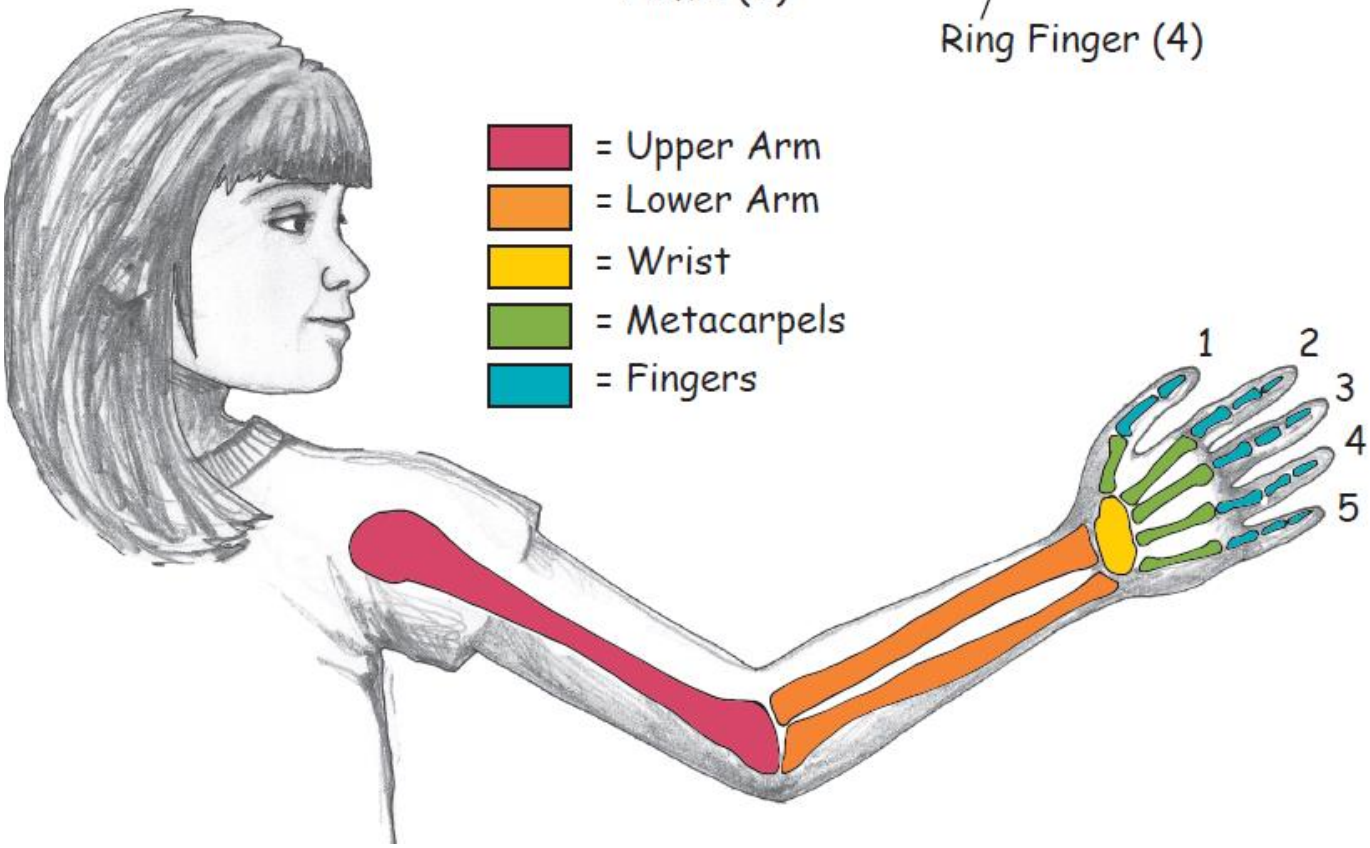
Math Problems:

1. How much do you weigh in grams? Remember that one pound equals 453.6 grams, so your weight X 453.6 = your weight in grams. Show your work!

2 Bats can eat about 1/2 their body weight in insects each night! How many Big Macs would you have to eat each night to eat the same amount of food as a bat? Hint, a Big Mac weighs about 0.5 lbs.

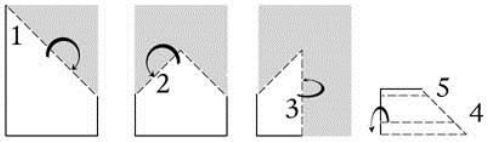
How do I Compare to a Bat?





Bat Paper Airplane from

Bats at the Library



1. Fold on line 1 away from this side.
2. Fold corner down along line 2 away from this side.
3. Fold in half along line 3, so bat faces out.
4. Fold wings out along line 4, and wing tips up along line 5.

Common Core State Standards - Math

Grade 2

Measure and estimate lengths in standard units.

CCSS.MATH.CONTENT.2.MD.A.1

Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.

CCSS.MATH.CONTENT.2.MD.A.4

Measure to determine how much longer one object is than another, expressing the length difference in terms of a standard length unit.

Grade 3

Solve problems involving measurement and estimation.

CCSS.MATH.CONTENT.3.MD.A.2

Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l).1 Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.

Lesson 2: Meet the Rhody Bats

Theme
Biologists collect annual data on bats in order to learn more about their populations and health. Data collection over time is an important part of wildlife conservation.

Learning Objectives
In this lesson, students will learn about the bat species of Rhode Island, and the current monitoring efforts being conducted by the Rhode Island Division of Fish and Wildlife.

Corresponding Activities for this Lesson
- Working the Night Shift *(Note: This activity includes some of Rhode Island's bat species, as well as species from different states.)*

Materials
- Lesson 2 PowerPoint
- Mist net sample
- RI bat species cards

Lesson
1. Show students the pictures of Rhode Island's bat species. *Ask students if they can spot some similarities and differences between the bats. Ask students to guess which bats might be the most common, and which might be the rarest.*
- Explain that the big brown and Eastern red bats are the most common species, and that the little brown used to be more common than it is today. The Northern long-eared bat is listed as Threatened under the Endangered Species Act. The Eastern small-footed bat has been documented in Rhode Island, but not in a long time. Hoary, silver-haired, and tri-colored bats are seen occasionally.
    - *Ask students why they think some bat species are more common than others, or why some bat populations are threatened/declining. After brainstorming, ask students to keep these predictions in mind. Threats to bats will be covered in the next lesson.*

2. Ask students what Rhode Island biologists may want to study about bats.
- Show students sequence of photos and videos of Rhode Island biologists capturing/banding bats, counting bats, and acoustic surveys. Pass around the mist net fragment for students to feel and see up close. *Information about each bat research project can be found in the notes section of the PowerPoint.*

Working the Night Shift – Biometric Clues (Eastern U.S.)

EXPLORATION QUESTION

"Why do we need to study bats and what methods can we use?"

MATERIALS

- Toothpicks (cut to size)
- Bat models or lunch bags with paper clips/beans/sand inside
- Metric rulers
- Metric scales (less than 30 grams)
- Latex, vinyl, or cloth gloves
- Student Inquiry, Instruction, and Evaluation Sheets
- Bat Survey Data Forms
- Dichotomous Key
- Identifying Features (table)
- Clue cards for each bat species
- PowerPoint presentation (optional)
- PowerPoint narrative (optional)

OVERVIEW

Students will learn and perform data collection techniques used in the field by bat biologists. They will measure and weigh "bat models," record data, and determine bat identification by using data collected, clue cards, and a dichotomous key. Students will also learn about White-Nose Syndrome and other threats to bats.

VOCABULARY

Biometric, calcar, endangered, extinction, forearm, fungus, harp trap, hibernate, membrane, mist net, species, tragus

GROUP SIZE

Any

AGE

13 and above (variations included for younger and older students)

Background

In general, bats are difficult to study because they are active at night, extremely fast fliers, roost in inconspicuous places (like caves and cracks in bridges), and they can move great distances in short periods of time. For these reasons, one of the greatest limitations to the conservation of bats is a lack of information on basic bat biology and ecology.

Although bats account for almost a quarter of all mammal species (there are more than 1,300 species of bats worldwide), bats are by far the least studied of all mammals. Bats occupy almost every habitat in the world eating tons of insects nightly, pollinating flowers, and dispersing seeds that grow new plants and even trees. Bats are our most important natural predators of night-flying insects consuming mosquitoes, moths, beetles, crickets, leafhoppers, chinch bugs, and much more! Many of these insects are serious crop or forest pests, and others spread disease to humans or livestock. Every year bats save us billions of dollars in pest control by simply eating insects. All but four of the 47 bat species found in the United States and Canada feed solely on insects. The remaining species feed on nectar, pollen, and the fruit of cacti and agaves in southwestern deserts.

Are bats in trouble?

Bats are in decline nearly everywhere they are found. Bat numbers in the United States and Canada have declined dramatically as a new disease, White-Nose Syndrome (WNS), has killed over six million bats in just six years. This disease is killing bats as they hibernate in caves and mines. Named for a cold-loving, white fungus typically found on the faces and wings of infected bats, WNS causes bats to awaken more often during hibernation. As a result, they use up their stored fat reserves which are needed to get them through the winter. Affected bats often emerge too soon from hibernation and are seen flying around in winter. These bats usually freeze or starve to death. More than half of the bats that live in the United States hibernate in caves and mines to survive the winter. Four of these bats are federally endangered (Indiana, gray, Virginia and Ozark big-eared bats) and live within or near WNS-affected areas.

The impact of WNS is frightening! Up to 99% of bats in some WNS-infected populations die within a few years. Little brown bats, once the most common bat in the northeastern United States, may be in danger of regional extinction within the next 15 years. Yet, WNS is just one of many threats that face bat populations. Other threats include habitat loss, pesticide use, wind energy development, oil and gas exploration, residential and industrial development, disturbance of hibernating bats, and improper eviction of bats from buildings. There is an urgent need to protect our bats!

In the United States, nearly 40 percent of our bats are endangered or are considered at risk. For example, gray bats were among our most abundant mammals just a century ago. Now, they are federally endangered which means they are in danger of extinction within the foreseeable future throughout all or a significant portion of their range.

How do we learn about bats?

One way that bat biologists gather information about bats is by conducting surveys. Surveying bats helps us learn what bat species are living in a given area (during a particular season) and how their populations are doing. By monitoring bats we can discover the factors that are important for their survival and identify which species need action now. We can also learn which areas are important for bats and need to be protected. When surveys are conducted year after year, biologist can detect increases or decreases in the size of a bat population. This long-term monitoring may be critical to understanding the overall impact of WNS and other threats to bats.

Bat biologists often conduct annual surveys to learn about bats by using mist nets, harp traps, or by observing bats in caves during hibernation. These types of studies allow easy standardization of data collection, hands-on examination, and reduce the chance of misidentifying species. Some species of bats can be difficult to identify and scientists must use a variety of characteristics to determine a bat's species. Your students will have a chance to hone their identification skills by learning some of these characteristics and by using a dichotomous key to learn others.

How do scientists tell one type of bat species from another?

To identify a bat, it is necessary to recognize the features that distinguish one species from another. Before you can give a bat a species name, you must first sort features of the animal into groups of similar and dissimilar traits. Biologists collect biometric data (measuring right forearm lengths, weighing bats, observing fur color, etc.) to identify bat species. This can be done very quickly by using a dichotomous key. Such keys include minute details about shapes and sizes of the parts of organisms that are being keyed out. Most bats that are found in the United States are not difficult to sort and identify into basic types when you know what characteristics to focus on. Others, like myotis species, are difficult to distinguish and morphological measurements are a necessity. And in some cases, biologists may even have to resort to genetics to determine species.

Where do you search for bats?

Bats use a variety of habitat types. When selecting sites to survey for bats, scientists often choose potential travel corridors, such as wooded streams, trails, and maintained rights-of-way. Rivers, streams, ponds, and lakes are also good places to search for bats because many bat species hunt for insects over water and almost all need to drink daily. Some bats use caves or other natural cavities such as rock outcrops with crevices, cliff faces, or even exfoliating bark on trees to roost, hibernate, and raise their young.

Bats can even be found in buildings. Agricultural buildings (e.g. farmhouses, barns, and outbuildings) of traditional wood, brick, or stone construction and/or with exposed wooden beams, and buildings and structures with slate roofs, stone walls, hanging slates, hanging tiles or weather boarding, are attractive to bats. This is especially true when these buildings are located near woods and/or water. Bats are also found in structures such as tunnels, mines, cellars, air raid shelters, bridge structures, and aqueducts. You just never know where you might find a bat!

Get Ready – Set Up Stations

1. Set up stations for each bat species to be measured.

2. Use the table, "Lengths and Weights - Bat Measurement Stations," to cut toothpicks to the correct length and to fill lunch bags with the correct weight. If you have bat models, place them at each station.

Each station needs:

- Gloves
- Toothpick cut to proper length (measure length of toothpick in millimeters)
- Bag with paper clips/beans/sand (weigh bag contents in grams) or bat model
- Clue card for one bat species
- Metric Ruler and metric scale

Get Set -Background Activities

1. Provide students with copies of the Student Inquiry Sheet.

2. Pose the questions on the sheet to students and ask them to design a data collection protocol for bat species identification through answering these questions or other questions they might develop.

3. Explain how bat biologists collect data on individual bats using the PowerPoint presentation, "Working he Night Shift –Biometric Clues." You could give students copies of the PowerPoint note pages and/or copies of the Background Information.

Go! - Measurement and Identification Activity

1. Give the students the following handouts and have them move to the stations:

- Student Instruction Sheet
- Bat Survey Data Form (for recording measurements and observations)
- Dichotomous Key for "Working the Night Shift - Eastern U.S. Bat Species"
- Optional – PowerPoint Notes Page from presentation to take notes on or write down follow-up questions

2. At the stations have the students work through the instructions on the Student Instruction Sheet.

3. After students have identified all of their bat species, provide them with copies of the table Eastern U.S. Bat Species: Identifying Features. Have the students verify their identifications are correct.

Go Even Further – Additional Activities

Here are a few additional activities that you can do with the students. These activities will build on how scientists collect data to study bats.

Please see "Further Reading Resources" for links to these resources.

- Read aloud one or more paragraphs of "An interview with Arizona-Sonora Desert Museum Bat Biologist – Karen Krebbs"
- Watch "The Battle for Bats: Surviving White-Nose Syndrome" (14 minutes). Ask students to list at least five ways bat biologists collect data.
- See scientists measuring bats, watch the interview with John Whitaker in "Cave: Life beneath the Forest" (4 minutes).
- Remind your students that now bat biologists ALWAYS wear gloves when handling bats.

1. Provide students with copies of the Student Evaluation Sheet.

2. Allow the students discussion time on how their data collection process related to the scientists in the films. Also allow for the students to discuss what can be learned by collecting bat data and how that data can be used. For example, what management actions might need to be implemented on the national forest to help protect bats?

Reflect – Evaluation

1. Accurately measure forearm lengths and bat weights

2. Record all data completely.

3. Correctly navigate the dichotomous key.

4. Correctly identify bat species and include supporting evidence.

5. Correctly answer questions about bat data collection. (Refer to "Teacher Answer Page" for general answers).

Extension - Install a Bat House

Installing a backyard bat house is a great way to provide a home for bats and to collect real-world data on a bat population. Bat houses are especially important in areas where there are few natural roosting sites such as large trees or caves. There are a variety of designs of bat houses and you can either make your own or purchase one. Consider placing a bat house in your community or encourage students to install one in their own backyard. One thing is for sure; your bat-tenants will pay you back with some wonderful benefits.

Bats are amazing animals that are vital to the health of our environment and economy eating tons of insects nightly. In temperate latitudes, like the United States, the bat species that are most likely to occupy a backyard bat house are insectivores that eat agricultural pests and some of the nasty bugs that harass outdoor gatherings (a.k.a. mosquitoes).

Your students will enjoy learning more about bats as they watch them come and go from the home you provided. And homes are often in short supply for bats. Their populations are declining around the world, often because of disappearing habitat.

Bats need time to find and explore new homes, so it may take a few years before your bat house has residents. Once they arrive, your students can start a monitoring program to count bats. The Wisconsin Department of Natural Resources has great information about their program and this could easily be modified for your home or classroom.

Consider building your bat boxes out of materials that are repurposed from other uses. For example, the Organization for Bat Conservation has been helping scouts build bat boxes out of used wood pallets. Can you think of other materials that could be used to build bat boxes? What about no longer needed wood furniture?

Just remember, if you use scrap wood that has been pressure-treated, it can only be used if you paint or stain over it. Pressure-treated wood contains chemicals that may be toxic to bats.

Suggested Resources:

Bat Conservation International - Artificial roosts
http://www.batcon.org/index.php/resources/for-specific-issues/artificial-roosts

Bat Conservation International – Install a bat house
http://www.batcon.org/index.php/resources/getting-involved/install-a-bat-house?highlight=WyJiYXQiLCJob3VzZSIsImJhdCBob3VzZSJd

Organization of Bat Conservation – Why bat houses are important
http://www.batconservation.org/bat-houses

Wisconsin Department of Natural Resources – Build a bat house
http://dnr.wi.gov/topic/wildlifehabitat/bathouse.html

Wisconsin Bat Program –Monitoring Program
http://wiatri.net/Inventory/Bats/

Further Reading and Resources – Discover More

About Bat Biologists:

An interview with Arizona-Sonora Desert Museum Bat Biologist – Karen Krebbs
www.desertmuseum.org/kids/bats/bat_biologist.php

An interview with John Whitaker in “Cave: Life Beneath the Forest” at
www.cavebiota.com/media/whitaker1.wmv

Discovery Channel. Dirty Jobs: Bat Biologist
www.discovery.com/tv-shows/dirty-jobs/videos/bat-biologist.htm

About Bats:

Bats in Your State - Species Profiles -
http://www.batcon.org/index.php/resources/media-education/species-profiles.

Hanging Around with Bats -
http://www.tpwd.state.tx.us/learning/resources/keepitexaswild/bats/

About White-Nose Syndrome:

Battle for Bats: Surviving White-nose Syndrome - http://vimeo.com/76705033

National White-Nose Syndrome (WNS) Website –
http://whitenosesyndrome.org/

Lengths and Weights - Bat Measurement Stations

Bat Species	Right Forearm Length* (toothpick length in millimeters)	Body Mass* (paperclips/beans/sand in grams)
Big brown bat *Eptesicus fuscus*	44 – 48 47	13 – 25 17
Gray bat *Myotis grisescens*	41 – 46 44	5 – 10 6
Indiana bat *Myotis sodalis*	36 – 40 38	5 – 11 7
Little brown bat *Myotis lucifugus*	35 – 40 35	5 – 14 7
Northern long-eared bat *Myotis sepentrionalis*	35 – 39 35	5 – 10 5
Tri-colored bat *Perimyotis subflavus*	32 – 34 33	4 – 7 4
Virginia big-eared bat *Corynorhinus townsendii virginianus*	42 – 47 45	9 – 12 11

*** We have provided examples for these measurements in case you wish to make your own bat models. These numbers will maximize the number of similar sizes that you will need to cut out. You can use any number within the range listed.**

Teacher Answer Page

1. What kinds of data do bat biologists collect? How do they collect the data?

- Time
- Temperature
- Sex
- Condition of Wing
- Date
- Weight (in grams)
- Fur color and length
- Length measurements (ear, forearm, toe hair length, tragus, etc.)
- Location of Survey
- Age (juvenile or adult)
- Presence of Calcar
- Reproductive Condition

2. Why do bat biologists need biometric data from individual bats? Why do they make detailed records of the data?

- To identify bat species
- To quantify bat's health
- To track the health of bats over time – Are there changes in wing damage or weights?
- To determine a range of sizes for particular bat species
- To determine sex ratios and reproductive condition/success

3. Why do bat biologists need several kinds of information (biometric measurements, physical characteristics observations, behavioral observations) to correctly identify bat species?

Some bats have very similar appearances and even the length of their forearm and weight may be the same. Bat biologists need to look at a variety of information to correctly identify individual bat species. For example, a keeled calcar is one of the key diagnostic features that helps distinguish the Indiana bat from the little brown bat. These species are often very confusing for people just learning to identify bats.

4. If bat biologists had good baseline data, what changes in the data would they observe after White-Nose Syndrome has infected bats in an area?

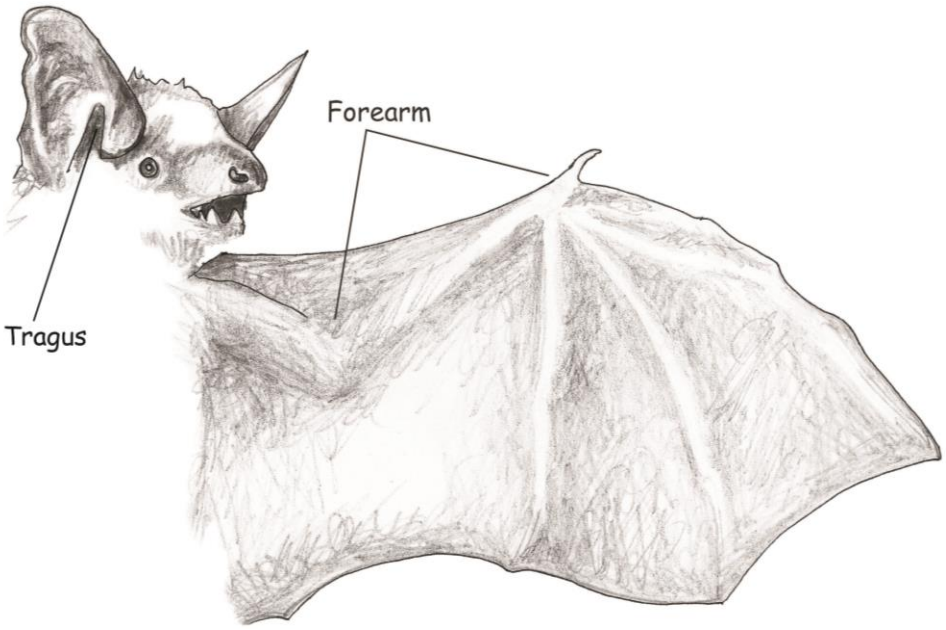
- Fewer bats
- Some species may be affected more by WNS than other species
- Lower body weights
- Bats may not be reproducing as a result of poor health or a lack of mates
- More wing lesions

Bat Clue Cards:

Bat 1 is the big brown bat
Bat 2 is the gray bat
Bat 3 is the Indiana bat
Bat 4 is the little brown bat
Bat 5 is the northern long-eared bat
Bat 6 is the tricolored bat
Bat 7 is the Virginia big-eared bat

Calcar – a projection of cartilage that extends from the ankle of a bat along the edge of the tail membrane towards the tail; provides support during aerial turns.

Forearm - the part of a mammal's arm extending from the wrist to the elbow; in bats, measurements of its length are often used to identify one species from another.



Muzzle – the nose and mouth of an animal. When WNS is present on a bat, it is often seen on the muzzle.

Tragus – a tiny fingerlike projection of skin-covered cartilage in front of a bat's ear.

Keeled Calcar – a well-defined spur made of cartilage that extends from the ankle towards the tail.

A. Calcar Not Keeled B. Calcar Keeled

Tail Membrane – the area of skin which joins the legs and/or tail of a bat. The membrane may attach at the ankle or at the toe. This can be important for species identification.

Variation for Older Students:
Bat biologists also record information on the sex of each bat collected and their reproductive condition (e.g. are females lactating). Ask students why this information is important and what management strategies might be developed from this information.

- A skewed sex ratio may indicate that one species is migrating earlier or later than the other (depending on the time of year).
- If only females or females and young are captured during surveys, you may have a maternity colony nearby - something worthy of finding and protecting.
- A main focus now is to determine if White-Nose Syndrome is having an impact on sex ratios and reproduction rate. This is an important issue because bats have such a low reproductive rate. Most bats in North America only have one pup a year. Think about how long it would take to rebuild a population that was reduced by 90% or more!

How do bat biologists identify bat species?
How do you think bat biologists can determine a bat's species? If you were going to collect data on a bat, what information would you need to help you determine a bat's species? What data would you collect? How would you collect the data? Where would you go to collect your data? A river? A forest? Your backyard?

One of the ways bat biologists study bats is by catching them, collecting biometric data (measuring right forearm lengths, weighing bats, looking at the color of fur, etc.), making observations, and using that information to identify species.

Where do bat biologists find bats?
Bats live in a wide variety of habitats. In the eastern United States, bat biologists look for bats near rivers and lakes where bats are hunting for insects or grabbing a drink of water. The top photo shows mist nets strung between two aluminum poles. Mist nets are usually made of nylon mesh suspended between two poles, resembling an oversized volleyball net. When properly set up, the nets are virtually invisible. You can't see the net and neither can the bats! Bats can also be found in forests and caves.

How do bat biologist catch bats?
Bat biologists catch bats in mist nets and harp traps. Harp traps are a metal frame strung with vertical monofilament line (like fishing line) with a bag at the bottom. Bats drop down to the bottom of the trap and are easily removed by biologists.

If bats are roosting in a cave, biologists can also just gently take them off the walls or ceiling of the cave, or they may just make observations of the bats. Sometimes, biologists even count the number of bats by using grids. Because bat biologists usually work at night or in caves, they need special clothing and lights.

How do bat biologists handle bats?
Bats are small and have delicate wings. To minimize damaging bat wings, biologists have special training and experience. Bat biologists always wear gloves when handling bats to avoid transmitting diseases to the bats and to avoid being bitten by bats. You should NEVER handle wild animals unless you have proper equipment, training, and vaccinations.

Why are there pictures of lunch bags on this page? Biologists actually store bats in lunch bags to keep them calm while transporting bats short distances and when there are lots of bats to identify and measure. Lunch bags are inexpensive.

Biometric measurements - right forearm
It's relatively easy for a trained biologist to hold a bat and extend the bat's wing in order to measure the right forearm. The forearm of a bat is the small bone at the top of the wing membrane, between the elbow and the thumb. Using a caliper or ruler, a biologist measures the length of the bat's right forearm, recording the data in millimeters.

Bat wings are one of the most remarkable features of a bat. A bat's wing is actually a modified hand and the wing bones are elongated fingers. This elongation of the bones is required to support the wing membrane. Compare the bones of the wing to the fingers on a human hand. Also point out the thumb. The thumb has a small claw, which aids the bat in crawling around on rough surfaces.

Biometric measurements - weighing bats
A bat can be weighed while it's still in a lunch bag or the bat can be transferred to a plastic container. When you do this step, remember that you need to tare the weight using an empty bag or container first. Bat biologists usually use a pan scale or a spring scale and record the bat's weight in grams.

Biometric clues - examining bat wings
Bat wings hold clues about a bat's health and can sometimes show if the bat has been infected with the fungus that causes White-Nose Syndrome. Bat wings are gently extended and held over a light box for careful examination. Do you see the difference between the healthy bat wing and the damaged bat wing? Sometimes bat biologists even use ultraviolet light to check for White-Nose Syndrome lesions on bat wings. What do you think would happen if a bat's wing was badly damaged?

The membrane of a bat's wing is living tissue similar to the tiny flaps of skin joining the bases of our human fingers. Bats have a much larger membrane of skin that joins their long fingers from the bases to the tips. A bat's fingers cannot flex independently, but the muscles in the arm can open up the hand. Do you think a bat's wing can heal over time?

Yes, sometimes bats get tears in their wings. A small tear in the wing up to about an inch doesn't cause the bat much trouble in flight. Since the bat's wing is living tissue, it can heal itself. But, if the wing is torn too badly, and the bat can't fly, then the bat would not be able to feed itself.

Observing physical and behavioral characteristics
You might spend a lot of time with your pet cat or dog. You can recognize them instantly! But what if a similar looking animal appeared on your front porch? Would you know if it was really your pet?

Bat biologists also spend a lot of time looking at bats. Sometimes they can instantly recognize a bat's species. Often it's more difficult. Scientists look at many physical characteristics to help identify bats. These include: age (juvenile or adult), sex, overall size, fur color, fur length, ear size, tragus size, tail membrane, calcar, and toe hair length. Explain some of the parts of the bat that students might not be familiar with including the tragus, calcar, and tail membrane.

A keeled calcar is a well-defined spur made of cartilage that extends from the ankle towards the tail. It provides support during aerial turns. The tragus is a tiny fingerlike projection of skin-covered cartilage in front of a bat's ear (after the activity, encourage students to look into the purpose of the tragus). The tail membrane is the skin which joins the legs and/or tail of a bat. The membrane may attach at the ankle or at the toe. All of these characteristic can be important for species identification.

Recording data
Now the biologists have all of this information. What do they do with it? First, they need to record it so they can refer to it later. Accurate records are really important for bat surveys. For example, bat biologists might want to compare bats' weight and health to previous years.

Who am I? Collecting your data
You, the bat biologist, will be recording the data that you observe on your Bat Survey Data Form including:

Time	Location	Weather
Weight	Right forearm length	Other Physical characteristics
Date	Behavioral characteristics	

You will take this data and use the dichotomous key to be sure to list the evidence that supports your identification of the bat species.

Student Inquiry Sheet

Working the Night Shift **Bat biologist (your) name**_____

First Things, First – Before Doing the Activity

You are a bat biologist. You have been asked to catch bats at a National Forest and identify the species of bats that are present.

1. How do you think bat biologists can determine a bat's species?

2. If you were going to collect data on a bat, what information would you need to help you determine a bat's species? What data would you collect? How would you collect the data?

3. What time of year would you collect the data? Where would you go to collect the most data on bats? Why?

Student Instruction Sheet

Start Your Bat Survey- Measurement and Identification Activity

1. Put on gloves to do these activities. Bat biologists now always work while wearing gloves. You might find that it's a little bit harder to do detailed work when you are wearing gloves. Why do you think it is important to wear gloves?

2. Weigh an empty lunch bag. Remember, you need to tare the weight at each station or you can subtract the weight of a bag from every bat weight measurement.

3. Make weight measurements of all bat models/lunch bags and measure toothpicks which represent the bat's right forearm. Be sure to record your data and information from the clue card on your Bat Survey Data Form. Include information about the bat's physical and behavioral characteristics.

4. Use your recorded data and the dichotomous key to determine the bat's species. Are you confident that you have made the correct identification? Be sure to write down any evidence that supports your identification of the bat species. Were any species similar? Do you think you could collect this data at night?

5. Use the Eastern U.S. Bat Species: Identifying Features to verify your findings.

Student Evaluation Sheet

What Did You Learn?

1. What kinds of data do bat biologists collect? How do they collect the data?

2. How did your data collection design match up to the activities performed in this activity? Did you identify the same types of information to collect to help you determine a bat's species?

3. Why do bat biologists need biometric data from individual bats? Why do they make detailed records of the data?

4. Why do bat biologists need several kinds of information (biometric measurements, physical characteristics observations, and behavioral observations) to correctly identify bat species?

5. If bat biologists had good baseline data about a bat population, what changes in the data would they observe after White-Nose Syndrome has infected bats in an area?

6. Do you think it is important to help bats?

7. How could you help bats around your school or home?

Bat Survey Data Form

Bat Biologist's Name: _____ Survey Location:_____

Date of Observation: _____ Time of Observation: _____ Weather Conditions: _____

Station Number	Right Forearm Length	Weight of Bat	Physical Characteristics	Behavioral Characteristics	Species Name	Evidence that Supports Your Identification of the Bat Species
1.						
2.						
3.						
4.						

Bat Survey Data Form

Bat Biologist's Name: _____ Survey Location:_____

Date of Observation: _____ Time of Observation: _____ Weather Conditions: _____

Station Number	Right Forearm Length	Weight of Bat	Physical Characteristics	Behavioral Characteristics	Species Name	Evidence that Supports Your Identification of the Bat Species
5.						
6.						
7.						

Other Observations:_____

Eastern U.S. Bat Species: Identifying Features

Bat species	Right forearm length (range in mm)	Body mass (range in grams)	Physical characteristics	Behavioral characteristics
Big brown bat *Eptesicus fuscus*	44 – 48	13 – 25	Large bat Distinctive brown fur Keeled calcar	Often found living in buildings Use many habitats
Gray bat *Myotis grisescens*	41 – 46	5 – 10	Tail membrane attaches at ankle (not at toe) No keel on calcar	Use caves all year, prefers to hunt over water
Indiana bat *Myotis sodalis*	36 – 40	5 – 11	Slightly keeled calcar Short toe hairs Less gradation of belly and back fur	Nickname “social myotis” because they pack tightly together when roosting
Little brown bat *Myotis lucifugus*	35 – 40	5 – 14	Feet bigger than Indiana bats, belly and back fur are different colors Toe hairs longer than toes No keel on calcar	Often found living in buildings Hibernate in large colonies in cool, humid caves
Northern long-eared bat *Myotis sepentrionalis*	35 – 39	5 – 10	Ears longer than other myotis bats Ear extends beyond nose by several mm if you lay ears forward Tragus is long and pointed	Often hunts under the tree canopy. Take down larger insects, carrying their catch to a branch to settle down and eat.
Tri-colored bat *Perimyotis subflavus*	32 – 34	4 – 7	Pink forearm Individual fur is tri-colored Small bats	Often roost alone
Virginia big-eared bat *Corynorhinus townsendii virginianus*	42 – 47	9 – 12	Really big ears, over 25 mm long	Use caves all year Prefer colder sections of caves

DICHOTOMOUS KEY

Working the Night Shift - Eastern U.S. Bat Species

1. A. Ears enormous, over 25 mm from notch to tip	***Corynorhinus townsendii virginianus***
B. Ears less than 25 mm from notch to tip	Go to 2
2. A. Calcar keeled	Go to 3
B. Calcar not keeled	Go to 4
3. A. Right forearm greater than 42 mm	***Eptesicus fuscus***
B. Right forearm less than 42 mm	***Myotis sodalis***
4. A. Wing membrane attaches to the foot at ankle (not at toe); hair on back uniformly colored from base to tip	***Myotis grisescens***
B. Wing membrane attaches to the foot at toe; hair on back not uniformly colored from base to tip	Go to 5
5. A. Fur tricolored from base to tip; right forearm less than 35 mm, tragus short and rounded	***Perimyotis subflavus***
B. Fur not tricolored from base to tip	Go to 6
6. A. Tragus long thin and pointed at tip; ears longer than 17 mm	***Myotis septentrionalis***
B. Tragus relatively short, rounded at tip; ears less than 17 mm	***Myotis lucifugus***

Clue Cards - Who Am I?

Photo by U.S. Fish and Wildlife Service

Bat 1 - Physical Characteristics

Ear Length: 16 – 20 millimeters (from notch to tip)

Calcar: keeled

Fur Color: tan to dark, chocolate brown

Tragus: broad with rounded tip

Other: robust jaws and teeth – feeds largely on beetles

Bat 1 - Behavioral Characteristics

- I use many habitats from lowland deserts to timberline meadows.
- I am often found living in buildings.
- I'm very beneficial – eating significant crop and forest pests including ground beetles, scarab beetles, cucumber beetles, snout beetles and stink bugs, as well as many species of moths and leafhoppers.
- I hibernate in caves.

Photo by U.S. Fish and Wildlife Service

Bat 2 - Physical Characteristics

Ear Length: 12 – 15 millimeters (from notch to tip)

Calcar: not keeled

Fur Color: darkish gray brown, hairs are uniform in color

Other: wing membrane attaches at ankle joint, not at the base of the toes

Bat 2 - Behavioral Characteristics

- I prefer hunting over water.
- I eat mosquitoes, caddis flies, stone flies, and other aquatic insects.
- I am very sensitive to disturbance. If disturbed, very young bats of my species may drop off the cave wall to the floor or into a stream.
- I use caves year round.
- I am Federally Endangered.

Photo by U.S. Fish and Wildlife Service

Bat 3 - Physical Characteristics

Ear Length: 9-15 millimeters (from notch to tip)

Calcar: slightly keeled

Fur Color: dull brown fur, faintly bi-colored

Other: small foot around 7 millimeters long

Bat 3 - Behavioral Characteristics

- My nickname is “social myotis” because I like to pack tightly together when roosting.
- I hibernate in caves, typically larger and cooler ones.
- I am Federally Endangered.
- I am vulnerable to disturbance because I hibernate in large numbers in only a few caves (the largest hibernation caves support from 20,000 to 50,000 bats).

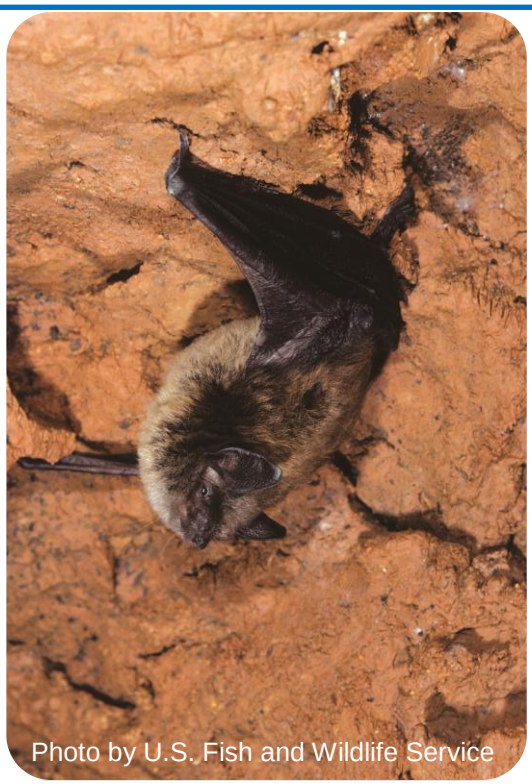


Photo by U.S. Fish and Wildlife Service

Bat 4 - Physical Characteristics

Ear Length: 12 - 15 millimeters (from notch to tip)

Calcar: not keeled

Fur Color: yellowish brown to olive brown, belly fur and back fur are slightly different color

Other: toe hairs longer than toes and wing membrane attaches to foot at toe

Tragus: relatively short and rounded at tip

Bat 4 - Behavioral Characteristics

- I am often found living in buildings
- I enjoy eating a variety of insects including midges, mosquitoes, mayflies, caddisflies, moths, beetles, and crane flies.
- My populations have been hit hard by White-Nose Syndrome.
- I hibernate in large colonies in cool, humid caves.

Clue Cards - Who Am I?

Photo by Al Hicks, NY DEC

Bat 5 - Physical Characteristics

Ear Length: 15-19 millimeters (from notch to tip)

Calcar: not keeled

Fur Color: reddish brown to brown

Other: ear extends beyond nose by several millimeters if you lay ears forward and the tragus is long and pointed. Wing membrane attaches to foot at toe.

Bat 5 - Behavioral Characteristics

- While small insects like caddisflies make up a large part of my diet, I can also take down larger prey. To eat the larger food, I carry my catch to a branch and settle down to eat.
- Populations of my species have been hit hard by White-Nose Syndrome.
- In summer I choose dense forests and I roost with my young under exfoliating bark and in tree cavities.
- I primarily hibernate in caves.

Photo by U.S. Fish and Wildlife Service

Bat 6 - Physical Characteristics

Ear Length: small ears, less than 12 millimeters (from notch to tip)

Calcar: not keeled

Fur Color: fur is golden brown to reddish brown and individual hairs are distinctly tri-colored

Other: forearm is pink, tragus is short and rounded, and wing membrane attaches to foot at toe

Bat 6 - Behavioral Characteristics

- I am a generalist when it comes to eating. I feed on small beetles, wasps, flies, and moths.
- I often roost alone.
- I am one of the few North American bats that often have two pups each year.
- I hibernate in caves, mines, and rock crevices.

Photo Craig Stihler, WV DNR

Bat 7 - Physical Characteristics

Ear Length: Enormous, over 25 millimeters (from notch to tip)

Fur Color: light to dark brown

Other: facial glands on either side of the snout are quite distinctive. Bat has short toe hairs.

Bat 7 - Behavioral Characteristics

- Moths make up a big part of my diet.
- I hibernate in clusters inside of caves, typically in the cooler sections.
- I am Federally Endangered.
- I use caves year round.
- When roosting or hibernating, I curl up my long ears so they look like ram horns.

Variation for Younger Students

Consider only using three bat species for this activity that can easily be distinguished from each other. The big-brown, tri-colored, and little brown bats can be identified based solely on weight and the length of the forearm.

Have younger students take these measurements and record their data. They can use the "Eastern U.S. Bat Species: Identifying Features" table to identify the species. Students can still collect data and identify a bat without going through a dichotomous key!

Answer to clue cards can be found on Teacher Answer Page.

Variation for Older Students

If available, borrow old mist nets from a local Department of Natural Resources, Forest Service, or Fish and Wildlife Service office. You can place the nets up in a darkened room such as a gymnasium. Have students put on gloves and headlamps. They will remove the bats from the nets, take measurements, and record the data in the dark.

Bat biologists also record information on the sex of each bat collected and their reproductive condition. Ask students why this information is important and what management strategies might be developed from this information?

Answer to clue cards can be found on Teacher Answer Page.

Curriculum/Standards Connections

Science Standards
Virginia science standards are listed here as examples. You can find citations for your state's standards by searching for the key words, "dichotomous key," "species," "binomial nomenclature," and "classify or classification."

Virginia Middle School Science – Life Science Standards
LS.5 The student will investigate and understand how organisms can be classified. Key concepts include:

a) the distinguishing characteristics of kingdoms of organisms;
b) the distinguishing characteristics of major animal and plant phyla; and
c) the characteristics of the species.

Skills

- compare and contrast key features and activities between organisms.
- classify organisms based on physical features.

Virginia High School Science – Biology Standards
BIO.7 The student will investigate and understand bases for modern classification systems. Key concepts include:

a) structural similarities among organisms;

Knowledge

- Binomial nomenclature is a standard way of identifying a species with a scientific two-word name. The first word is the genus name and the second the species name.
- A species is defined as a group of organisms that has the ability to interbreed and produce fertile offspring.

Skills

- Construct and utilize dichotomous keys to classify groups of objects and organisms.
- Describe relationships based on homologous structures.

Next Generation Science Standards

Middle School Life Science (for worksheet question and for extension activity)
MS-LS2-4. Ecosystems: Interactions, Energy, and Dynamics: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Common Core State Standards Connections:
ELA/Literacy -

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-4)
RI.8.8 Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-4)
WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4)
WHST.6-8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-4)

Making a Bat Model

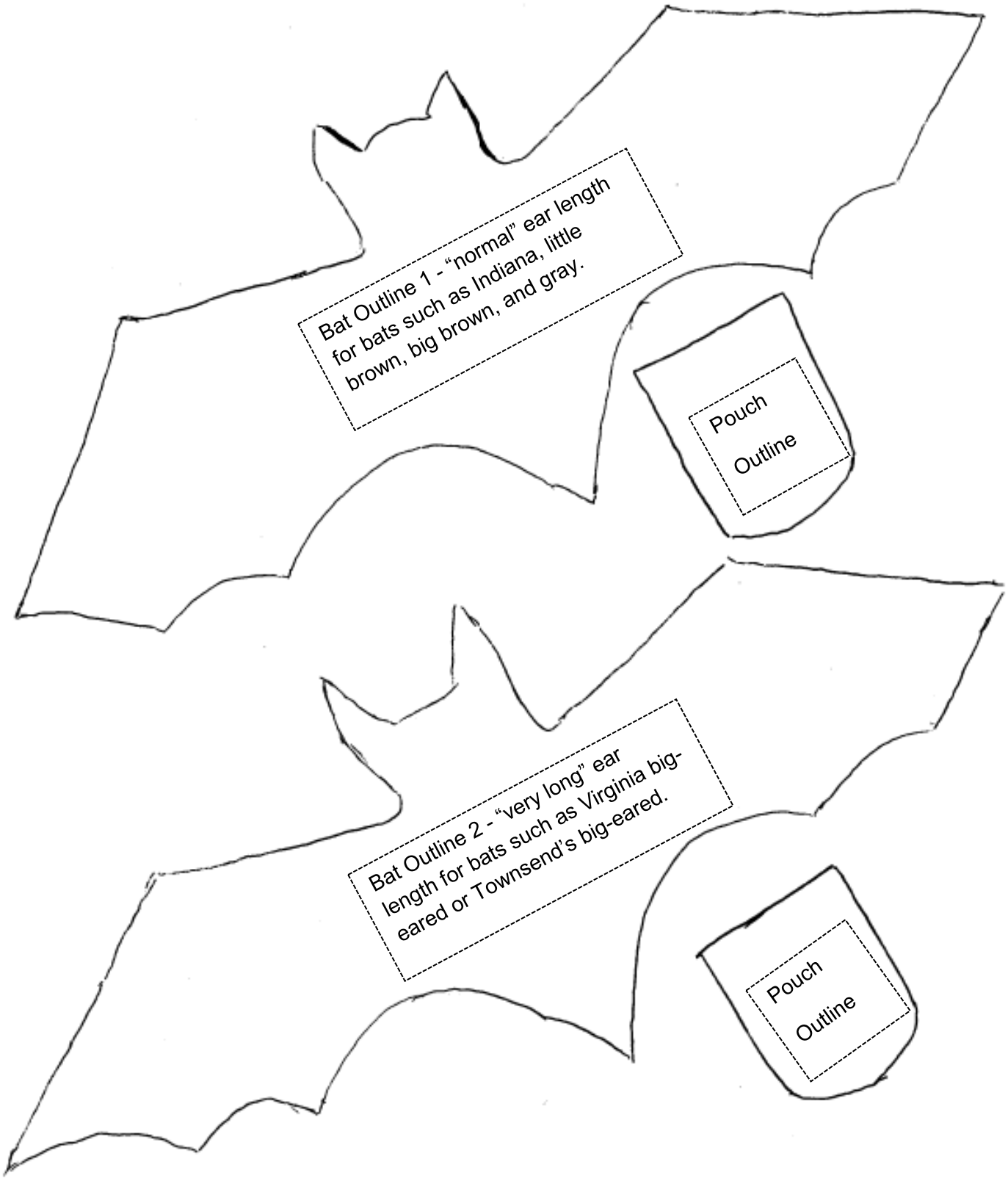
If you do not have access to one of the Project EduBat trunks, you may want to make your own bat models for the activity, “Working the Night Shift – Biometric Clues.” These are easy and fun to make. Included below, you will find templates for bats with a “normal” ear length and one with a “very long” ear length. We recommend that you use felt to make your bat models as this fabric is relatively inexpensive, fairly sturdy, easy to find online or in stores, and comes in a variety of colors. Here are some basic instructions.

Bat Body

1. Cut out the bat body outline and the pouch outline.
2. Use these to cut out bat shapes on the appropriate color of felt (brown, tan, cream, reddish, gray, etc.)
3. Sew the bottom three sides of the pouch to the bat outline in the center of the body.
4. Fill the pouch with fine materials until the bat is at the proper weight. We recommend using BBs, sand, round split shot fishing sinkers, or other small materials. Be sure to measure the bat using a scale and get an accurate weight!
5. Once the bat is the appropriate weight, sew the top of the pouch closed.

Bat Forearm

1. Cut toothpicks to the correct length for each bat species you are making. We recommend using flat toothpicks as they will be easier to sew onto the bat body.
2. Add several stitches around the toothpick to secure it to the bat’s body in the location of the forearm.
3. Add a touch of color to the end of the toothpick and create an identification key. That way, you will always know which bat model is which bat species (without having to weigh the bat and measure the forearm length).


Bat Outline 1 - “normal” ear length for bats such as Indiana, little brown, big brown, and gray.
Pouch Outline
Bat Outline 2 - “very long” ear length for bats such as Virginia big-eared or Townsend’s big-eared.
Pouch Outline

Finished Bat Models

Photo by U.S. Fish and Wildlife Service

Bat 1 - Physical Characteristics

Ear Length: 16 – 20 millimeters (from notch to tip)

Nose Leaf: absent

Fur Color: tan to dark, chocolate brown

Tail: does not extend beyond tail membrane

Tragus: broad with rounded tip

Bat 1 - Behavioral Characteristics

- I use many habitats from lowland deserts to timberline meadows.
- I am often found living in buildings.
- I'm very beneficial – eating significant crop and forest pests including ground beetles, scarab beetles, cucumber beetles, snout beetles and stink bugs, as well as many species of moths and leafhoppers.
- I hibernate in caves.

Photo by U.S. Fish and Wildlife Service

Bat 2 - Physical Characteristics

Ear Length: 12 – 15 millimeters (from notch to tip)

Calcar: not keeled

Fur Color: darkish gray brown, hairs are uniform in color

Other: wing membrane attaches at ankle joint, not at the base of the toes

Bat 2 - Behavioral Characteristics

- I prefer hunting over water.
- I eat mosquitoes, caddis flies, stone flies, and other aquatic insects.
- I am very sensitive to disturbance. If disturbed, very young bats of my species may drop off the cave wall to the floor or into a stream.
- I use caves year round.
- I am Federally Endangered.

Photo by U.S. Fish and Wildlife Service

Bat 3 - Physical Characteristics

Ear Length: 9-15 millimeters (from notch to tip)

Calcar: slightly keeled

Fur Color: dull brown fur, faintly bi-colored

Other: small foot around 7 millimeters long

Bat 3 - Behavioral Characteristics

- My nickname is “social myotis” because I like to pack tightly together when roosting.
- I hibernate in caves, typically larger and cooler ones.
- I am Federally Endangered.
- I am vulnerable to disturbance because I hibernate in large numbers in only a few caves (the largest hibernation caves support from 20,000 to 50,000 bats).

Photo by U.S. Fish and Wildlife Service

Bat 4 - Physical Characteristics

Ear Length: 12 - 15 millimeters (from notch to tip)

Calcar: not keeled

Fur Color: yellowish brown to olive brown, belly fur and back fur are slightly different color

Other: toe hairs longer than toes and wing membrane attaches to foot at toe

Tragus: relatively short and rounded at tip

Bat 4 - Behavioral Characteristics

- I am often found living in buildings
- I enjoy eating a variety of insects including midges, mosquitoes, mayflies, caddisflies, moths, beetles, and crane flies.
- My populations have been hit hard by White-Nose Syndrome.
- I hibernate in large colonies in cool, humid caves.

Photo by Al Hicks, NY DEC

Bat 5 - Physical Characteristics

Ear Length: 15-19 millimeters (from notch to tip)

Calcar: not keeled

Fur Color: reddish brown to brown

Other: ear extends beyond nose by several millimeters if you lay ears forward and the tragus is long and pointed. Wing membrane attaches to foot at toe.

Bat 5 - Behavioral Characteristics

- While small insects like caddisflies make up a large part of my diet, I can also take down larger prey. To eat the larger food, I carry my catch to a branch and settle down to eat.
- Populations of my species have been hit hard by White-Nose Syndrome.
- In summer I choose dense forests and I roost with my young under exfoliating bark and in tree cavities.
- I primarily hibernate in caves.

Photo by U.S. Fish and Wildlife Service

Bat 6 - Physical Characteristics

Ear Length: small ears, less than 12 millimeters (from notch to tip)

Calcar: not keeled

Fur Color: fur is golden brown to reddish brown and individual hairs are distinctly tri-colored

Other: forearm is pink, tragus is short and rounded, and wing membrane attaches to foot at toe

Bat 6 - Behavioral Characteristics

- I am a generalist when it comes to eating. I feed on small beetles, wasps, flies, and moths.
- I often roost alone.
- I am one of the few North American bats that often have two pups each year.
- I hibernate in caves, mines, and rock crevices.

Photo Craig Stihler, WV DNR

Bat 7 - Physical Characteristics

Ear Length: Enormous, over 25 millimeters (from notch to tip)

Fur Color: light to dark brown

Other: facial glands on either side of the snout are quite distinctive. Bat has short toe hairs.

Bat 7 - Behavioral Characteristics

- Moths make up a big part of my diet.
- I hibernate in clusters inside of caves, typically in the cooler sections.
- I am Federally Endangered.
- I use caves year round.
- When roosting or hibernating, I curl up my long ears so they look like ram horns.

Lesson 3: Bat Conservation

Theme
Biologists collect annual data on bats in order to learn more about their populations and health. Data collection over time is an important part of wildlife conservation.

Learning Objectives
In this lesson, students will learn about the threats bats face and how we can all do our part to help bats.

Corresponding Activities for this Lesson
- Bat Blitz
- Bat Mural
- There's a Fungus Among Us

Materials
- Lesson 3 PowerPoint

Lesson
1. Review with students the benefits of bats to humans and the ecosystem. *Ask students what they think would happen if bat populations were to decrease. Write students' answers on the board.*

2. Show students pictures of bats with White-Nose Syndrome, and explain that this disease has become the leading threat to bats across the United States.
- Define White-Nose Syndrome.
- Explain how this disease affects bats.
- Explain the origins of the disease and how quickly it has spread.
- You can see an interactive time lapse of the spread of White Nose Syndrome across the country at www.whitenosesyndrome.org.
- Explain that this disease does not directly affect humans, but could indirectly affect us. Circle back to students' ideas of what could happen if bats began to disappear.

- Explain that this disease has made its way to Rhode Island, discovered when our state biologists conducted sampling in the few known places where bats hibernate in the state.
- *Detailed information about White Nose Syndrome can be found in the notes section of the PowerPoint.*

3. **Ask students what they think everyone can do to help bats.**
    - **Create healthy habitat –** Plant a bat-friendly garden with lots of different plants. This will attract insects, and provide natural food for the bats.
    - **Don't use pesticides –** Chemical pesticides are often used to kill certain insect pests, but can end up unintentionally killing other insects too. This can impact bats because killing off insects greatly reduces their food source. Also, if an insect is sprayed, but does not die immediately, it could be eaten by a bat. The bat will have ingested the chemical pesticides via the insect. The poison can make its way up the food chain, eventually harming bats and other wildlife. This is a common occurrence with birds of prey eating rats that have consumed rat poison before becoming a hungry bird's lunch.
    - **Provide shelter –** Building a bat house can help give bats a place to rest. Bats are very site faithful, meaning they return to the same roosts and hibernacula each year. They may not find your bat house right away, but it's always good to offer them the option!
    - **Share what you know about bats with your friends and family! –** The more people know about bats, the better. Bats are often misunderstood, and need your help to spread the word that bats are super cool!

Bat Blitz (Modified from Project WILD)

How to:

1. Set up the playing field with foraging habitat on one side, and a cluster of hula hoops (or other markers) on the other side. Tell the students that the hula hoops represent roosting sites (where the bats go to sleep and rest, like a tree, cave, or barn) and that the open "field" is foraging habitat (where the bats go to find bugs to eat).

2. Set out cups or bags, one for each student. Randomly distribute tokens into 40% of the cups, and leave the remaining cups empty. To have enough tokens, multiply the number of students in the class by 7. *Example: For a class of 30 students, provide 210 tokens. Randomly split the tokens among 12 bags and leave the remaining 18 bags empty.*

3. Explain to students that they will either be little brown bats or insects, and that you will be playing 3 rounds of the game. Explain the following rules:

- Bats stand on a roosting site (in a hula hoop). During each round of the game, each bat must eat 1,000 insects, which is equivalent to 10 tokens. Each token equals 100 insects.
- Bats have to collect one token at a time, then have to return to their roost and count to 10 to simulate resting between foraging trips.
- Bats will have 2 minutes to forage.
- Insects fly around the foraging habitat. When tagged by a bat, the insect has to give the bat 1 token.
- If a bat gets 10 tokens, they are full, and must return to their roost for the rest of the round.
- When an insect runs out of tokens, they can stand on the side of the playing field.
- After each round, the class will work together to fill out the data table.

Bat Blitz Data Table

Round	How many bats? (Count # of bat students at beginning of round)	How many insects at start of round? (Count tokens and multiply by 100)	How many insects were eaten? (Count # of tokens in bat cups, multiply by 100)	How many insects survived? (Count # of tokens left in insect cups, multiply by 100)
1		Should be the same each round, fill this column in before starting game		
2				
3				

Round 1

Have the students count off in fives. Ones, twos, and threes will be bats. Fours and fives will be insects. Set a timer for two minutes, and release the bats to forage! At the end of the round, collect data for the data table.

Round 2

Explain to the students that White-Nose Syndrome has hit the bat colony during their winter hibernation. A bunch of the bats have sadly died due to the disease and have not returned to the summer roost. Use the same number of insect tokens from Round 1. Have the students count off in fives. Ones and twos will be bats, threes, fours, and fives will be insects. Repeat foraging and data collection as in Round 1.

Round 3

Explain to the students that White-Nose Syndrome has persisted, and that more bats did not make it through the winter. Use the same number of insect tokens from Round 1. Have the students count off in fives. Only ones will be bats this time, while twos, threes, fours, and fives will be insects. Repeat foraging and data collection as in Round 1.

Wrap Up:

At the end of three rounds, create a line or bar graph together to show the number of bats, the number of insects consumed, and the number of insects that survived in each round. Ask the students what role the bats played in the ecosystem, and what happened to the insect population when the bats population decreased due to White-Nose Syndrome. Ask the students how this could impact people.

About Project WILD

Project WILD's mission is to provide wildlife-based conservation and environmental education that fosters responsible actions toward wildlife and related natural resources. All curriculum materials are backed by sound educational practices and theory, and represent the work of many professionals within the fields of education and natural resource management from across the country.

To attend a FREE training workshop, email kimberly.sullivan@dem.ri.gov.

RHODY CRITTER KITS

DEM RHODE ISLAND

There's a Fungus Among Us – WNS Transmission

EXPLORATION QUESTION

"What is White-Nose Syndrome, how is it spread, and why is it important?"

MATERIALS

- Copies of Student Investigation Worksheet, Instruction Sheet, and Graph
- Black light/ultraviolet light source
- Powder laundry detergent with whitening agent (e.g. Ultra Tide with Acti-Lift crystals)
- Confectioner's Sugar
- Blue food coloring
- Paper towels
- Water

OVERVIEW

Students will investigate how infectious diseases are spread, focusing on the disease White-Nose Syndrome (WNS), and the scientific methods used to investigate diseases. Students will simulate the interactions of bats in a cave when bats are in close proximity and may spread WNS fungal spores. By coming into physical contact with other "bats," students will have the chance to test to see if they have been infected with WNS and observe how quickly the disease can spread. Students will also interpret graphs to learn about doubling effects, exponential equations, and population growth curves.

VOCABULARY

Endangered, extinct, hibernation, infectious disease, maternity colony, microbes, threatened, torpor

GROUP SIZE

15 or more

AGE

13 and above

Background

Infectious diseases are caused by microbes - organisms too small to be visible to the naked eye. The most common infectious disease-causing microbes are bacteria, viruses, fungi, and protozoa. Fungi are important causes of disease in wild birds and other species. Infections may occur when birds, bats, or other species have suppressed immune systems, when their mechanisms for inflammatory response are inhibited, or when they experience physical, nutritional, or other stress for prolonged periods of time. Add in high rates of contact between animals and you have the perfect conditions for the spread of infectious disease.

White-Nose Syndrome (WNS) is an emerging wildlife disease that is causing unprecedented declines in hibernating North American bats. More than half of the bats that live in the United States hibernate in caves and mines to survive the winter. Four of these bats are federally endangered (Indiana, gray, Virginia and Ozark big-eared bats) and live within WNS-affected areas.

First detected in New York in the winter of 2006-2007, WNS has spread south through the Appalachian Mountains and into the Southeast, north through New England and into eastern Canada, and west into the Great Lakes region and the Midwest. There is great concern that WNS will continue to spread across North America. In the northeastern United States and Canada, WNS has killed more than six million bats and has caused population declines greater than 90% in some populations.

The effects of WNS on North American bat populations has led the U.S. Fish & Wildlife Service to consider listing several of the most affected species for either threatened or endangered species status under the Endangered Species Act. Endangered species are those animals and plants that are in danger of becoming extinct throughout all or a significant portion of their range. Threatened species are those that are likely to become an endangered species within the foreseeable future throughout all or a significant portion of their range.

Infectious Disease Transmission – The Epidemiologic Triangle

The Epidemiologic Triangle is a model that scientists have developed for studying health problems. It can help your students understand infectious diseases and how they spread. In general, for infectious disease to occur, three basic components are required: an agent or microbe that causes the disease (the "what" of the Triangle), a susceptible host (the "who" of the Triangle), and a suitable environment that enables both the agent and the host to come into contact and allow for disease transmission (the "where" of the Triangle). These three components make up the corners of The Triangle (called vertices). In the case of WNS, the causative agent is the cold-adapted fungus, *Pseudogymnoascus destructans*; the host are hibernating bat species; and the environment consists of caves and mines in North America.

Hosts

Forty-four insectivorous species of bats exist in the United States, 25 of which hibernate in caves or mines during the winter. As of 2014, seven cave species have been confirmed to have WNS including the big brown, eastern small-footed, gray, Indiana, little brown, northern long-eared, and tri-colored (previously known as the eastern pipistrelle) bats. The gray bat and the Indiana bat were already federally endangered species prior to the emergence of WNS, and the northern long-eared bat is now proposed for listing due to severe population declines caused by WNS.

Bats are all relatively long-lived in the wild, typically around 10 years, with some cases of individuals living longer. Records exist for six bat species living longer than 30 years and for 22 species living more than 20 years in the wild. The oldest record is a male *Myotis brandii* living 41 years. Mating occurs in the fall and females typically give birth to one pup per year in the spring at maternity colonies. Maternity colonies are where female bats congregate to give birth and raise young during the summer. These areas normally are found in dead (and sometimes live) trees with exfoliating bark, tree cavities, caves, or in mines, but they may also be found in buildings. Because of the low reproductive capability of bats (most have one or two pups once a year) it is difficult for the population to recover from the mass die-offs caused by WNS.

The seven bat species affected by WNS survive winter--when their insect prey is unavailable-- by hibernating in the cold environments of caves or mines. During hibernation, there is very little food for bats to eat, so survival depends upon the regulated use of the fat deposits that were built up during the fall. Hibernating bats save energy by spending most of the time in a state of torpor. In torpor, bats allow their body temperature to decrease to the surrounding environment and they reduce their metabolic rate to about 2% of their normal resting rates. Other physiologic processes including respiration, cardiovascular output, and immune function are also greatly decreased to conserve energy. These are great conditions for invading microbes.

Throughout hibernation, bats will arouse or awake from torpor by raising their body temperature approximately every 10 – 14 days. These arousals are energetically expensive but are likely necessary to maintain hydration and essential body functions. Bats affected by WNS arouse more frequently during hibernation than unaffected bats. Bats quickly deplete their fat reserves and are unable to replenish them because insects are not available for food during the winter. Bats with WNS often exhibit unusual behavior, such as flying during the day in near-freezing weather.

The Disease Agent

White-Nose Syndrome is caused by a newly discovered, cold-loving fungus named *Pseudogymnoascus destructans* or *Pd*. The term "White-Nose Syndrome" comes from the visible white growth of this fungus on the muzzle and other parts of the bat during hibernation. The fungus grows most often on the hairless portions of the body, such as the wings, ears, muzzle, and tail of hibernating bats. However, the fungus can also persist in the environment in the absence of bats and can grow in the cave or mine environment even when bats are not present.

Bats may be infected with the fungus for a period of time before they show visible signs of WNS. The fungus invades the surface of the skin, causing damage to the underlying connective tissue, blood vessels, and muscles. In severe cases, holes and tears can occur in the wing membrane due to the extensive cellular damage. Bat wings comprise 85% of the body surface and are important for controlling body temperature, blood circulation, water balance, and gas exchange. Damage to the wing membrane not only inhibits flight, but more importantly disrupts crucial physiological functions during torpor. Disruption of these vital processes due to WNS leads to life-threatening dehydration, electrolyte imbalances, and acid-base disturbances.

The rapid spread and mass mortality associated with the disease suggests that WNS is a newly introduced disease to North America (i.e. a non-native invasive species). In addition, *Pd* has been found on hibernating bats and within hibernacula across Europe. These infections in bats have been associated with wing damage (characteristic for WNS), but there have been no reports of mass mortalities caused by WNS in Europe. These observations provide evidence that *Pd* may have been introduced into North America from Europe.

Environment

Many North American bats spend significant portions of their lives underground in caves or mines where microclimates remain relatively constant throughout the year. Bats use this stable environment to hibernate over the winter and for daily rest during the remainder of the year. Some bats even use this environment in the summer to raise their young. Unfortunately, the cold and stable microclimates in a cave also provide ideal conditions for the growth of *Pd*.

Bats are able to fight off infection during the summer when they are active, but their immune system is greatly reduced when they hibernate. This provides a long window for the growth of *Pd*. Additionally, *Pd* can persist in the underground environment without the presence of bats. This means that once a cave or mine is contaminated with *Pd*, it remains contaminated and can serve as a reservoir to uninfected bats that visit. As more sites become contaminated, more bats are infected.

Transmission

Transmission of *Pd* occurs both through direct contact between bats and contact between bats and contaminated environments. Hibernating bats can congregate at high densities in caves and mines to overwinter. During hibernation, bats often cluster together and touch one another. This allows for the direct transfer of fungal spores between bats. Fungal spores are also deposited on the walls and ceilings when infected bats touch these surfaces. Fungal spores persist on walls, ceiling, and in the ground substrate. Uninfected bats touch these surfaces and spores are transferred indirectly. So, direct bat to bat contact is not necessary for spores to spread.

Movement of Pseudogymnoascus destructans

A number of hypotheses exist to describe the movement of *Pd* across the landscape. Bats infected with *Pd* that emerge early from hibernacula may move to new sites and spread the fungus. Transmission between bats during the fall when bats are mating before they enter hibernacula is also likely. Infected bats that survive the winter may spread the fungus as they migrate to summer roosting sites that are occupied with bats from other locations. It is also possible that humans and other animals moving between caves may carry fungal spores from one place to the next. Future research will offer more concrete evidence on how WNS is moved across the landscape.

White-Nose Syndrome Detection

Clinical signs of WNS infection in bats include the white fuzzy fungal growth on hairless skin and varying degrees of wing membrane damage. However, not all infected bats display clinical signs and other means are required to effectively diagnose infection. Ultra-violet (UV) light causes WNS fungi that are invading skin cells to fluoresce (glow) and it can be used as a preliminary WNS screening tool. Unfortunately, fungal spores present on the bat which have not begun invasion of the skin and fungal spores in the environment (i.e. hibernacula walls, ceilings, and substrate), do not fluoresce. Microscopic examination of the skin and genetic testing for *Pd* DeoxyriboNucleic Acid (DNA) from bats or environmental samples are required for definitive detection of WNS. In this activity, the teacher will simulate looking for fungal spores on “infected” students.

Treatment

Currently, effective means of WNS treatment do not exist. Management efforts have focused on slowing transmission and improving bat survival. Research on effective anti-fungal agents is ongoing but it is important to remember that hibernacula are very sensitive ecosystems. Applying chemical treatment to bats or the environment may have unforeseen and unintended consequences. For example, microbes and fungi are the foundation of cave food webs and could be wiped out with chemical treatments. Furthermore, the logistics of medicinally treating wildlife populations is often unpractical.

Get Ready – Background Activity

1. Assess your students’ knowledge of infectious disease by asking questions such as:
How do people get sick?
What are some symptoms?
What are some ways to keep from getting sick?
Do wildlife species get sick?
What symptoms do they have?

2. Clarify the difference between infectious disease and non-infectious disease, such as those caused by nutritional deficiencies or other environmental factors or genetic abnormalities.

3. Ask students what kinds of things cause infectious disease. Discuss some of the ones that students have heard of or that have been in the news.

4. Hand out the Student Investigation Worksheet, "The Epidemiologic Triangle." This background activity can be done in class or may also be given as a homework assignment. Tell your students they are now going to learn about how epidemiologists or "disease detectives" study an infectious disease. They use a method called *The Epidemiologic Triangle*.

5. Ask a student to read the definition of "agent" written on the Student Investigation Worksheet. This is the "What" of *The Epidemiologic Triangle*. Ask the class if they know the agent for any of the diseases that they discussed earlier. Most of them will not. Tell them that the information is available to doctors and scientists and they will be doing some research to determine the "agent" that causes White-Nose Syndrome, a disease that has killed over six million bats in just six years.

6. Ask another student to read the definition of "host." This is the "Who" of *The Epidemiologic Triangle*. Under this section, students will also describe the symptoms of the disease that a "host" may experience. These may be clinical signs or other symptoms.

7. Ask a student to read the definition of "environment." This is the "Where" of *The Epidemiologic Triangle*.

8. Tell the students they are going to become epidemiologists, looking at a devastating disease that is killing bats in the United States and Canada as they hibernate. Students will research and describe the agent, the host (including symptoms of the disease), and the environment by using the following resources: "Battle for Bats: Surviving White-Nose Syndrome" film (available at http://vimeo.com/76705033) and brochure (available at https://www.whitenosesyndrome.org/resource/battle-bats-brochure-july-2013-pdf).

9. When students have completed the activity, review their answers in class. Be sure to clearly point out to the students that any disease can be understood by looking at the agent, host, and the environment.

Get Set - Set Up Stations

1. If needed, consult your school's safety standards for using black light sources in the classroom.

2. You will need a good quality black light/ultraviolet light source. Make sure that it is working before preparing the activity. This activity is structured so that the teacher keeps the light source and supervises its use with each student. Checking one student's hand to see if it is "infected" (fluoresces) can be done with just one light source. You will also be able to give a quick "no" or "yes" to students who are not sure if they are "infected."

3. Many laundry detergents have blue specks. You will need to prepare two mixtures including "WNS infected" and "uninfected" and make sure that the two mixtures look similar. This is done by creating a mixture that is laundry detergent and sugar combined at a one to one ratio (WNS infected) and a second mixture that is sugar and sugar dyed with blue food coloring also at a one to one ratio (uninfected).

4. To keep the "infected" student's identity a secret, you will need to plan ahead. You can have students close their eyes when they place their hands in the powder. You can switch bowls (without students seeing the switch) to "infect" just one student. You could also designate a trustworthy student to be the "infected" student and work out a way for them to secretly place their hand in the laundry detergent powder. Or, you can have the mixtures in a box. Students will reach their hand into hole at the top of the box without seeing which mixture is being used. You can switch the bowls without the students knowing.

Go! – Transmission Activity

1. Before you begin the activity, ask one student to place one moistened hand in the sugar mixture and one moistened hand in the laundry detergent/sugar mixture. Show the entire class what an infected vs.

non-infected hand looks like under black light.

2. Give each student a copy of the Student Instruction Sheet. Have the students write down their name at the top of the sheet and then work through the directions.

3. After students complete their graphs, review the data as a whole class.

4. Discuss doubling effects, exponential functions, and population growth curves.

5. Discuss the ecosystem implications of 95% bat mortality after WNS infection.

Go Even Further – Additional Activities

Here is an additional activity that you can do with your students. This activity will build on how WNS is spread. Bats also transmit fungal spores by landing/roosting in their environment (e.g. on cave walls and ceilings) and leaving spores. Other bats then land/roost on the same place and pick up the spores.

To simulate this environment-to-bat (indirect) transmission, repeat the main activity, but have students touch designated roost areas (desk tops or other appropriate surfaces in the classroom). Students (bats) become infected when they touch a surface that has been infected by a student (bat) that was carrying spores.

Reflect – Evaluation

1. Accurately fill out "The Epidemiologic Triangle."

2. Student worksheet complete; Correct and thoughtful answers to all questions.

3. Graph complete; Data points match worksheet numbers.

Extension – Descriptive Writing
Invite students to use descriptive writing to describe the spread of WNS throughout their state. Encourage them to think about blogs, magazine articles, journals, stories, and even email. Prompt them to talk about why good descriptions make writing better and more interesting. Explain to students that they will be writing their own piece of descriptive text. Depending on the amount of time available, you may want to assign a specific kind of descriptive writing like a journal or letter, or you may allow students to pick their own format. Remind them that capturing this event will involve focusing on details and using all five senses. Here are some questions they might ask themselves: What does the disease look like? What might I hear or see in a cave that has been infected by WNS? What can I smell inside the cave? How does losing these bats make me feel? How does their loss affect me, my community, and my state? Encourage the students to use a thesaurus to find new and specific words. For example, instead of the word cave, a thesaurus may suggest different ideas such as cavern, grotto, fissure, cavity, etc.

Further Reading and Resources – Discover More

About White-Nose Syndrome:

Battle for Bats: Surviving White-Nose Syndrome - http://vimeo.com/76705033

National White-Nose Syndrome (WNS) Website – http://whitenosesyndrome.org/

National Wildlife Health Center - http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/

Overview of Current Knowledge for Land Managers - http://www.treesearch.fs.fed.us/pubs/45305

Screening for WNS using UV light - http://www.jwildlifedis.org/doi/abs/10.7589/2014-03-058

About Infectious Diseases

BAM! Teacher's Corner from the Center for Disease Control and Prevention - http://www.cdc.gov/bam/teachers/

Disease Detectives - http://www.diseasedetectives.org/

Teacher Answer Page

There's a Fungus among Us - WNS Disease Transmission

Background Activity

What is an infectious disease?
Infectious diseases are disorders that are caused by organisms — such as bacteria, viruses, fungi or parasites – that are transmitted from animal to animal by direct or indirect contact. Malaria, measles, and chickenpox are examples of infectious diseases in humans. White-Nose Syndrome, avian influenza, chronic-wasting disease, and rabies are examples of infectious diseases that affect wildlife.

Non-infectious diseases (often known as non-communicable diseases) are those that are caused by factors such as genetics, environment, and lifestyle. They are not caused by disease-causing organisms and do not pass from one animal to another.

The Epidemiological Triangle and WNS - The **Agent** of WNS is a cold adapted fungus, *Pseudogymnoascus destructans* also referred to as *Pd*.

The **Host** of WNS is hibernating bats found in North America. **Symptoms** include:

- fungal growth on the muzzle, wings, ears, and tail of hibernating bats;
- invasion of the surface of the skin by the fungus causing damage to the underlying connective tissue, blood vessels and muscles;
- wing damage including holes and tears; and
- abnormal behaviors such as flying outside during the day in near-freezing temperatures or clustering in a cave entrance during winter.

The **Environment** of WNS consists of caves and mines in North America.

Interaction questions

How many bats were infected?

1 interaction	2 infections
2 interactions	4 infections
3 interactions*	8 infections*
4 interactions*	16 infections*
5 interactions*	32 infections*

* Your class infection numbers might be slightly less than these idealized numbers, even as early as the three interactions round. If an infected bat (student) interacts with an already infected bat (student), no new "infections" will happen.

10. Think about your answer to "after 5 interactions." How many students are in your class? What happens to your graph when you run out of bats (students) to infect?
When there are no new bats (students) to infect, the graph line will fall back to zero. Some students might also note that the curve will begin to flatten out as the number of healthy individuals that are available to be infected decreases.

Whole group discussion

1. Our class data roughly illustrates the doubling effect. What function equation could you use to draw this effect? (Hint: It's a very simple exponential equation.)

$y = 2^n$ - an exponential equation where y equals 2 to the nth power

To broaden the discussion, educators could introduce the topic of "super-spreaders." In wild populations, not all infected individuals in a population have equal chances of transmitting infection to others. In what has become known as the 20/80 rule, a small percentage of individuals in a population have often been observed to control most transmission events. These "super-spreaders" exhibit a higher ability to infect others. The 20/80 rule is a concept documented by observational and modeling studies that has profound implications for infection control, 20% of the individuals within any given population are thought to contribute at least 80% to the transmission potential of a pathogen. Many host-pathogen interactions have been found to follow this empirical rule.

2**. What will happen in an ecosystem if 95% of the bats die from White-Nose Syndrome?** Bat biologists are currently working on the answer to this question. Like most areas of environmental science and biological research, there is no simple answer. Students should recognize that the near-elimination of bats from an ecosystem could have dramatic effects on population dynamics of bat prey (e.g., insects) and on bat predators (e.g. snakes and many mammals).

You could also introduce the idea that bats are considered a keystone species in many cave systems. The droppings of cave-roosting bats (called guano) provide vital nutrients for cave ecosystems and are often the basis of a cave's food chain. This guano is used by microorganisms and invertebrates, which become food for fish, salamanders, frogs, and other larger animals.

Because of the low reproductive capability of bats (most have one or two pups each year) it is difficult for the population to recover from the mass die-offs caused by WNS. Many bat species do not reproduce until they are two years or older.

To take it further, bats also play a significant role in science and medicine. Research conducted on bats has led to advancements in sonar, vaccine development, blood anti-coagulation, and more. For example, scientists used enzymes taken from vampire bat saliva to develop a blood-clot dissolving drug called Draculin. Draculin is now used for the treatment of strokes and heart attacks! What other discoveries might we make as we continue to learn about bats?

Student Investigation Worksheet

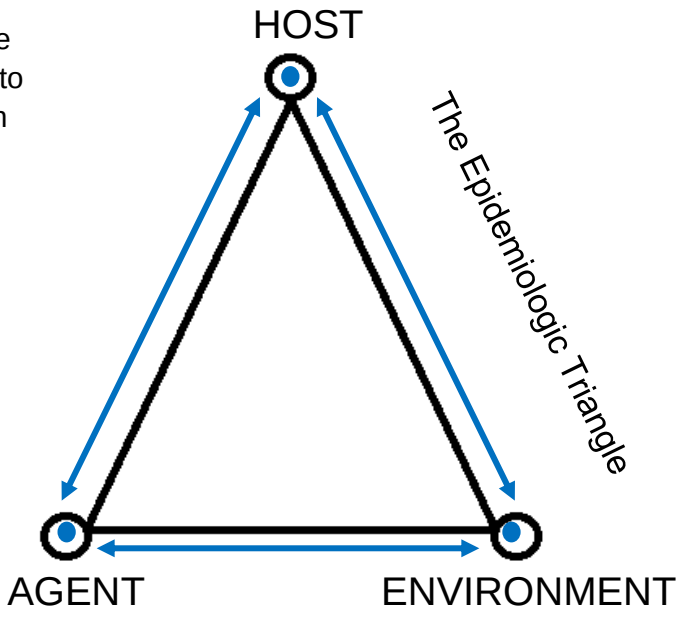
The Epidemiologic Triangle **Student's Name:**_____

You will learn a scientific method of problem-solving used by epidemiologists or "disease detectives" to study an infectious disease. This method can be applied to diseases of humans and wildlife. Like investigators at the scene of a crime, disease detectives look for clues and gather information about what happened. They ask questions like: Who or what is sick? What are their symptoms? When did they get sick? Where could they have been exposed to the illness?

The Epidemiologic Triangle is a model that scientists have developed for studying health problems and wildlife diseases, specifically to understand infectious diseases and how they spread. The Triangle has three corners which are called vertices.

Vertex 1. The Agent is the cause of the disease and usually is a microbe, an organism too small to be seen with the naked eye. Most people call an agent a "germ." The agent is the "What" of *The Epidemiologic Triangle*.

My research on the "agent" for White-Nose Syndrome shows that it is:



Vertex 2. The Host is an organism, usually a human or other animal, which has been exposed to and harbors a disease. The host can be the organism that gets sick or any animal carrier that may carry the disease and not get sick. The same microbes affect different hosts in many different ways. The host is the "Who" of *The Triangle*.

My research on the "host" for White-Nose Syndrome (including symptoms of the disease) shows:

Vertex 3. The Environment is the favorable surroundings and conditions outside the host that cause or allow the disease to be transmitted. For example, some diseases live best in dirty water while others can survive only in blood or living tissue. The environment is the "Where" of *The Epidemiologic Triangle*.

My research on the "environment" for White-Nose Syndrome shows:

Student Instruction Sheet

There's a Fungus among Us **Student's Name** _____

You will simulate one way, physical contact, that bat biologists believe White-Nose Syndrome spores are spread by bats.

Round One - One Interaction

1. Wash your hands and rinse them thoroughly. Wipe one hand (your non-writing hand) on a wet paper towel.

2. Gently pat your hand in the container of powder. Your hand represents a bat and the powder represents WNS fungal spores. One of your classmates (maybe you?) has placed their hand in powder that is "infected" with WNS fungal spores.

3. Walk around the room and choose another bat (student) to interact with. During your interaction, you will firmly shake hands. DO NOT TOUCH YOUR POWDERED HAND ON ANYTHING ELSE IN THE ROOM!

4. Return to your seat.

5. Estimate how many bats (students) you think will be infected. _____

6. To find out who is infected, wait until your teacher calls you to place your hand under the black light source. If you interacted with the original infected bat (student), you will see brightly glowing specks under the black light.

7. How many bats (people) were infected? _____

8. Wash your hands thoroughly again, especially if you were "infected."

Round Two – Two Interactions

1. Wash your hands and rinse them thoroughly. Wipe one hand (your non-writing hand) on a wet paper towel.

2. Gently pat your hand in the container of powder. Your hand represents a bat and the powder represents WNS fungal spores.

3. You will do another round of interactions with other bats. Once again, only one bat (student) will be "infected" at the beginning of this activity. This time, you will interact with <u>two</u> different bats (students). Walk around the room and choose another bat (student) to interact with. During your interaction, you will firmly shake hands. DO NOT TOUCH YOUR POWDERED HAND ON ANYTHING ELSE IN THE ROOM!

4. Find another bat (student) and repeat the handshake as described in step 3.

5. Return to your seat.

6. Estimate how many bats (students) you think will be infected after <u>two</u> interactions. _____

7. Test your hands again to find out how many bats (people) were actually infected._____

There's a Fungus among Us (continued)

Round Three - Three Interactions

You will do one more round of interactions with other bats. Once again, only one bat (student) will be "infected" at the beginning of this activity. This time, you will interact with three different bats (students). You will complete steps 1-2 listed above.

3. You will complete three rounds of interactions with other bats (students). Once again, only one bat (student) will be "infected" at the beginning of this activity. Walk around the room and choose another bat (student) to interact with. During your interaction, you will firmly shake hands. DO NOT TOUCH YOUR POWDERED HAND ON ANYTHING ELSE IN THE ROOM! Repeat this step two more times.

4. Return to your seat.

5. Estimate how many bats (students) will be infected after three interactions. _____

6. Test your hands again to find out how many bats (people) were actually infected._____

7. Graph how the number of infected bats (students) increased with the number of interactions. To help you make the graph, think about the following questions:

Graph Q1. How many bats (students) were infected before you started the first round of interactions? _____

Graph Q2. How many bats (student) were infected after just one round of interactions? _____

Graph Q3. How many bats (student) were infected after two rounds of interactions? _____

Graph Q4. How many bats (student) were infected after three rounds of interactions? _____

More interactions

8. Use the graph to predict how many (bats) students would become infected after four interactions. _____

9. How about after 5 interactions? _____

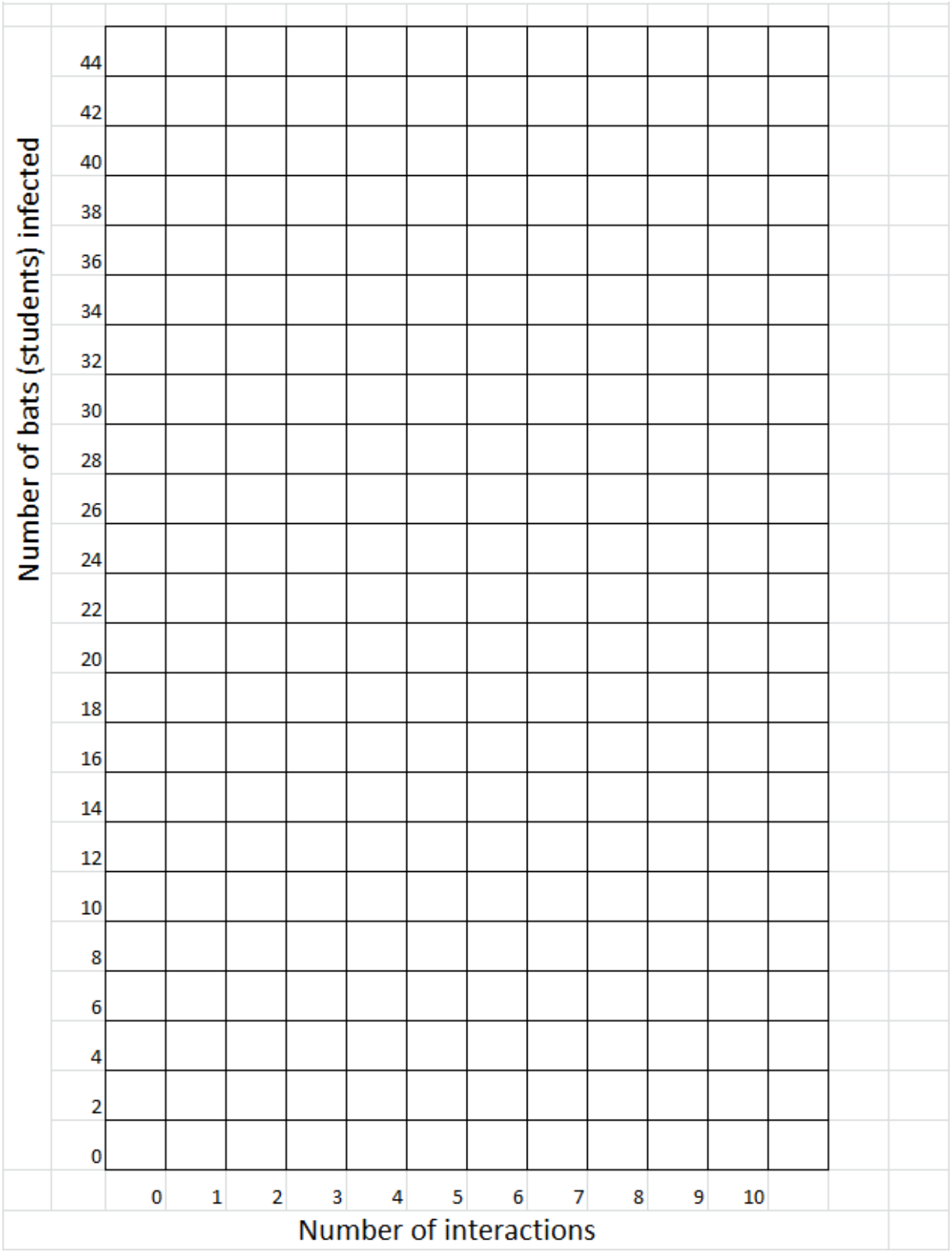
10. Think about your answer to "after 5 interactions." How many students are in your class? What happens to your graph when you run out of bats (students) to infect?

Whole group discussion

1. Our class data roughly illustrates the doubling effect. What function equation could you use to draw this effect? (Hint: It's a very simple exponential equation.)

2. What will happen in an ecosystem if 95% of the bats die from White-Nose Syndrome?

Student Graph - White-Nose Syndrome Transmission



Curriculum/Standards Connections

Common Core State Standards: Math: High School

CCSS.MATH.CONTENT.HSF.IF.C.7.E
Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.

CCSS.MATH.CONTENT.HSF.IF.C.8.B
Use the properties of exponents to interpret expressions for exponential functions. For example, identify percent rate of change in functions such as $y = (1.02)^t$, $y = (0.97)^t$, $y = (1.01)12^t$, $y = (1.2)^t/10$, and classify them as representing exponential growth or decay.

Next Generation Science Standards

Middle School Life Science

MS-LS2-4. Ecosystems: Interactions, Energy, and Dynamics: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

High school Life Science

HS-LS2-6 Ecosystems: Interactions, Energy, and Dynamics: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

A Teacher's Guide to the Project EduBat Bat Mural

This beautiful mural captures the amazing diversity of bats in the United States. There are 47 species of bats in the United States and all of them are beneficial to people. Most bats feed on insect pests and some bats even help in pollination. Scientists study bats to further expand our understanding of flight, sound, sonar and evolutionary biology. The mural is designed from east *(right side)* to west *(left side)* and features important bats from these different regions of the United States. Each bat is chosen to represent a special benefit that bats provide or an important bat conservation concept. Use this "cheat sheet" as a guide to transform this fun activity into an educational one as well.

Bats Eat TONS of Pesty Insects!

Bats are the primary predator of night-flying insects. A single bat can eat up to 100% of their body weight (that's more than 4,000 insects) each night! Insect-eating bats, like the **cave myotis**, **Townsend's big-eared bat**, and **little brown bat** pictured here, are opportunistic, and feed on all sorts of insects including moths, beetles, crickets AND mosquitoes! Some of their favorite prey are crop-destroying pests like cucumber beetles and corn-borer moths. Scientists estimate the agricultural value of bat's natural pest-control to be between $3 and $23 BILLION each year!

Bats Are Important Pollinators!

There are more than 1,300 species of bats in the world—and in tropical areas, many of them are critical pollinators for plants and more than 300 kinds of fruit, like bananas, guavas and mangoes.

In the southwestern United States, some of our bats are pollinators too. The **lesser long-nosed bat** pictured here, pollinates agave plants, and the saguaro and organ pipe cactuses. Drawn to the fragrant, pale, night-blooming flowers, lesser long-nosed bats bury their furry faces in the bloom to lap nectar. They emerge, covered with pollen, and carry it to the next flower they visit.

YOU can be a Bat Champion!

We need bats in our lives, but bats also need our help! There are many things that you can do to help bats. Here are some ideas:

- Learn more about bats, and share your understanding about the value of bats with others.
- Take care of the habitat that bats need—like forests and caves.
- Join with scientists to help monitor bat populations.
- Install bat houses to provide summer habitat for bats and places where bats can gather to raise their young.

Healthy Forests Need Healthy Bats – and Healthy Bats Need Healthy Forests!

Bats are incredibly important to the health of our forests. They eat tons of forest pests like gypsy moths and emerald ash borers that can decimate forests if left unchecked.

But bats need healthy forests too! Many species of bats, like the **tri-colored bat** and **hoary bat** pictured here, depend on forests for roosting and summer habitat. Bats, either individually or in small groups, often roost in tree cavities or under loose bark during the daylight hours, and emerge at dusk to feed on forest insects. Bats need healthy, well-managed forests that have both old and young trees. Even standing, dead trees can be important for bats!

Caves are VERY Important for Bats!

Caves across the United States, and the world, provide critical habitat for many species of bats. Some species, like the **gray bat** pictured here, spend their entire lives tied to caves. They roost, raise their young and hibernate in caves. Other species, like the **little brown bat**, use caves during the cold winter months as a safe place to hibernate.

In the eastern United States and in Canada, a new, deadly fungus lives in some bat caves. This fungus causes White-Nose Syndrome, and is responsible for killing more than six million bats in just six years. Scientists are hard at work trying to slow the spread of White-Nose Syndrome, and are investigating ways to minimize its deadly impacts.


Cave myotis
Townsend's big-eared bat
Little brown bat
Tricolored Bat
Northern long-eared bat
Hoary Bat
Lesser long-nosed bats
Gray bats
EDUBAT
Education Taking Flight

Create a HUGE Bat Mural!

This bat mural from Project Edubat can be used as a great classroom project! The following pages provide 8.5" X 11" sections of the mural that can be taped together to form a 42" X 55" work of art! Simply print them off and tape them together, according tothe following guide sheet.

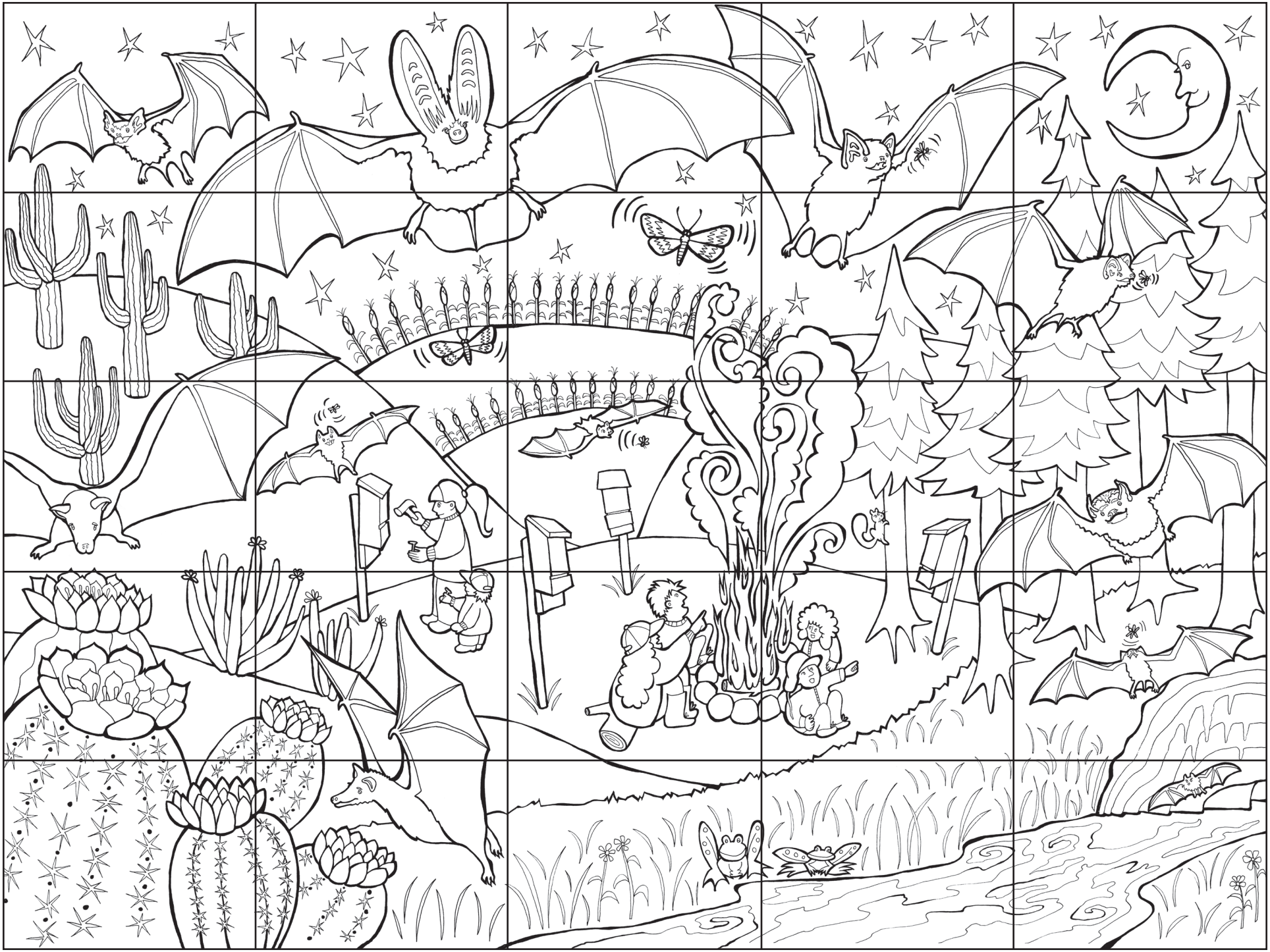
Have your students investigate the bat species featured on the mural, and the habitats they depend on.

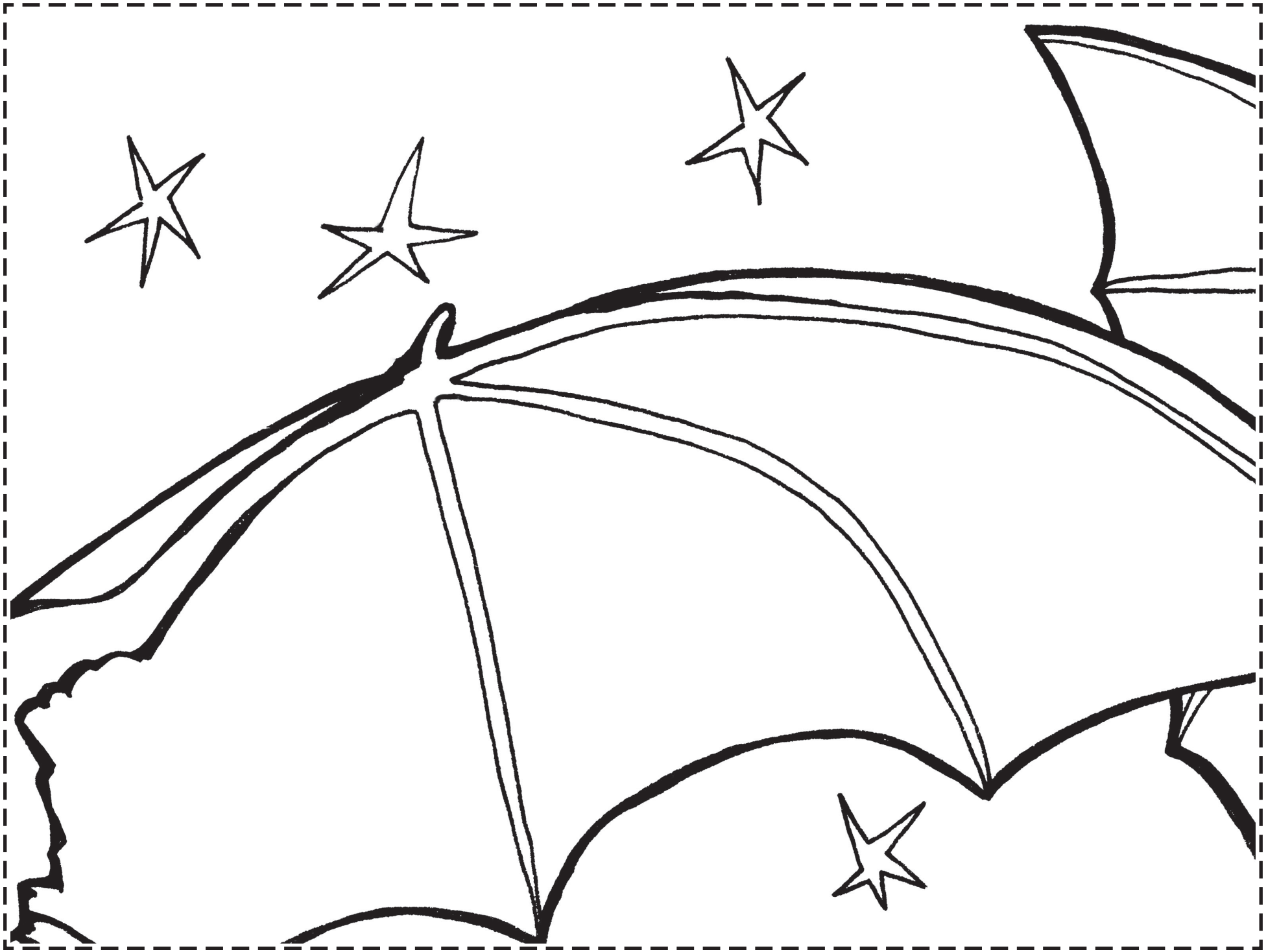
Each student can color a page or several pages, and the sheets can be collected and arranged for a beautiful and meaningful collaborate work of art.

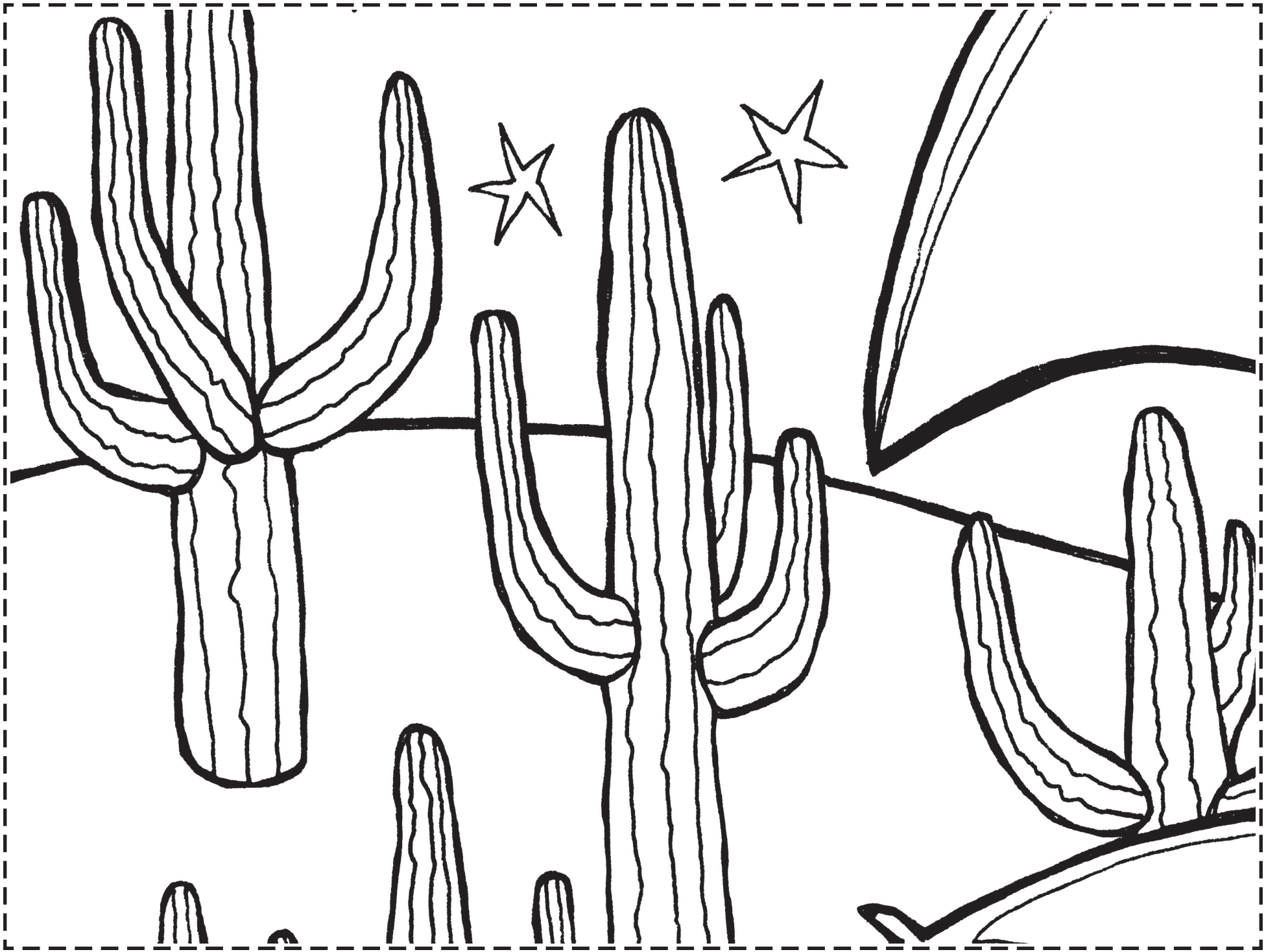
For more information about bats, be sure to visit the BatWeek website at www.batweek.org.

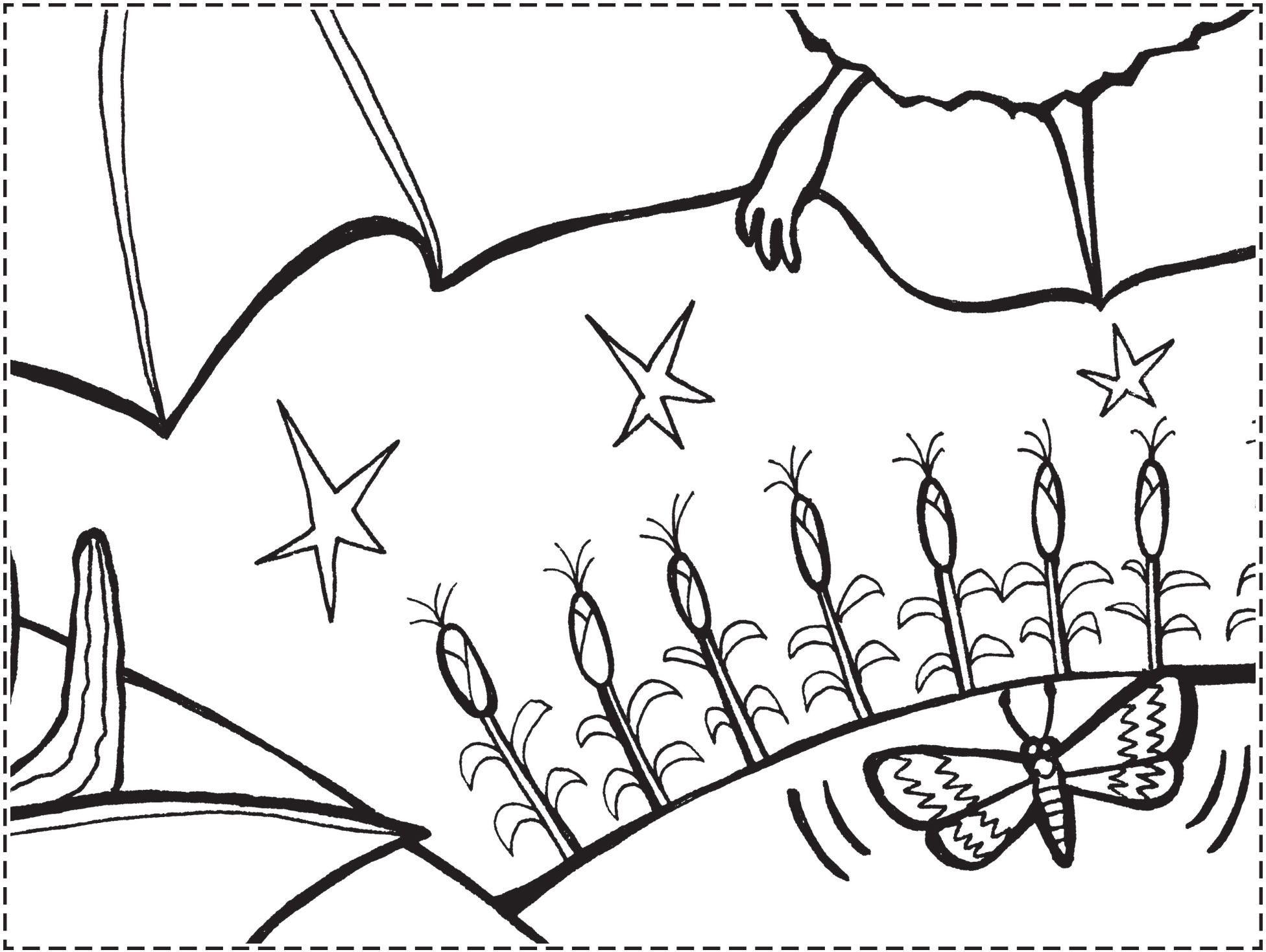
BATWEEK www.batweek.org

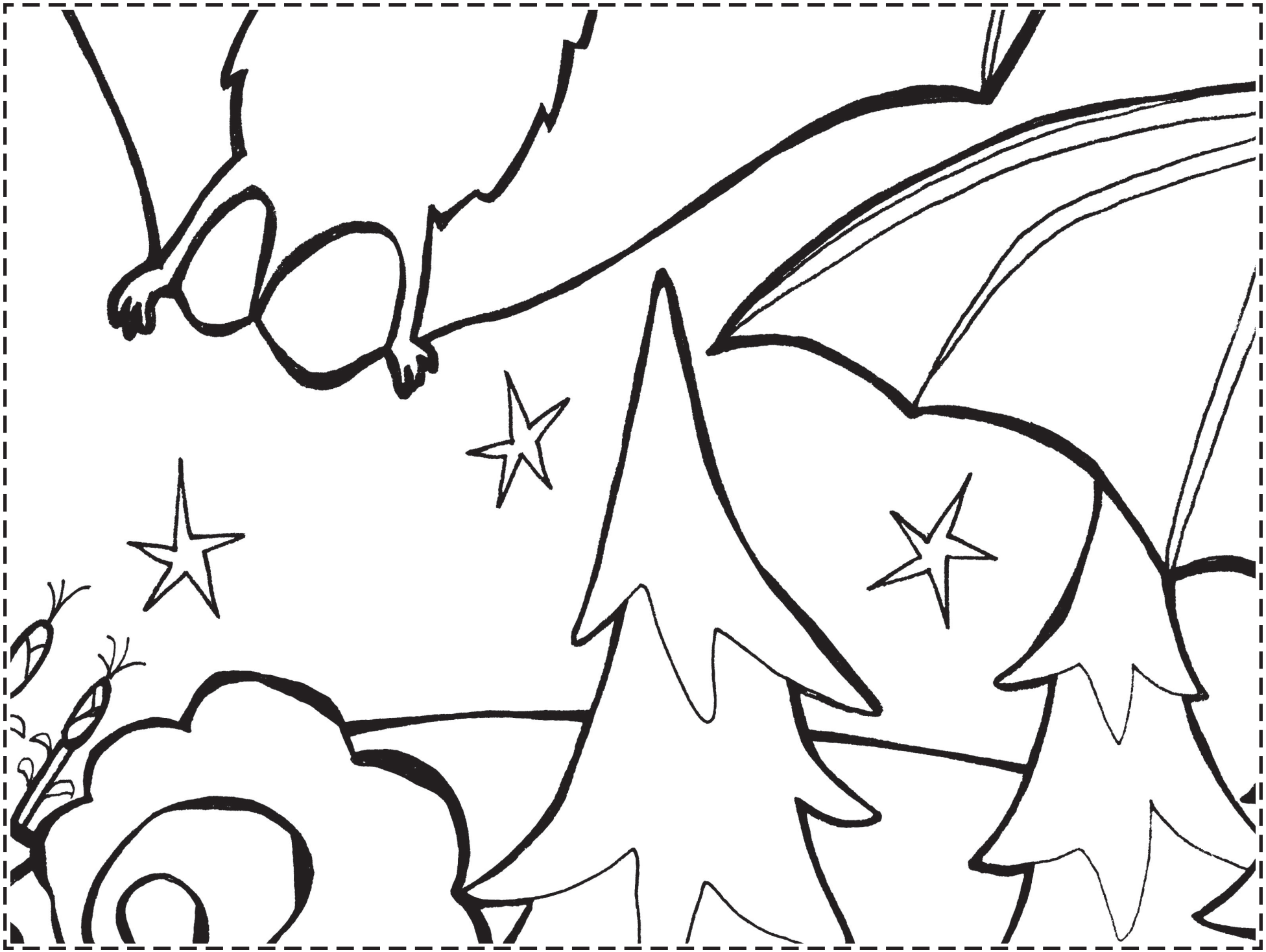
Go to Bat for Bats!
Oct. 24-31, 2017

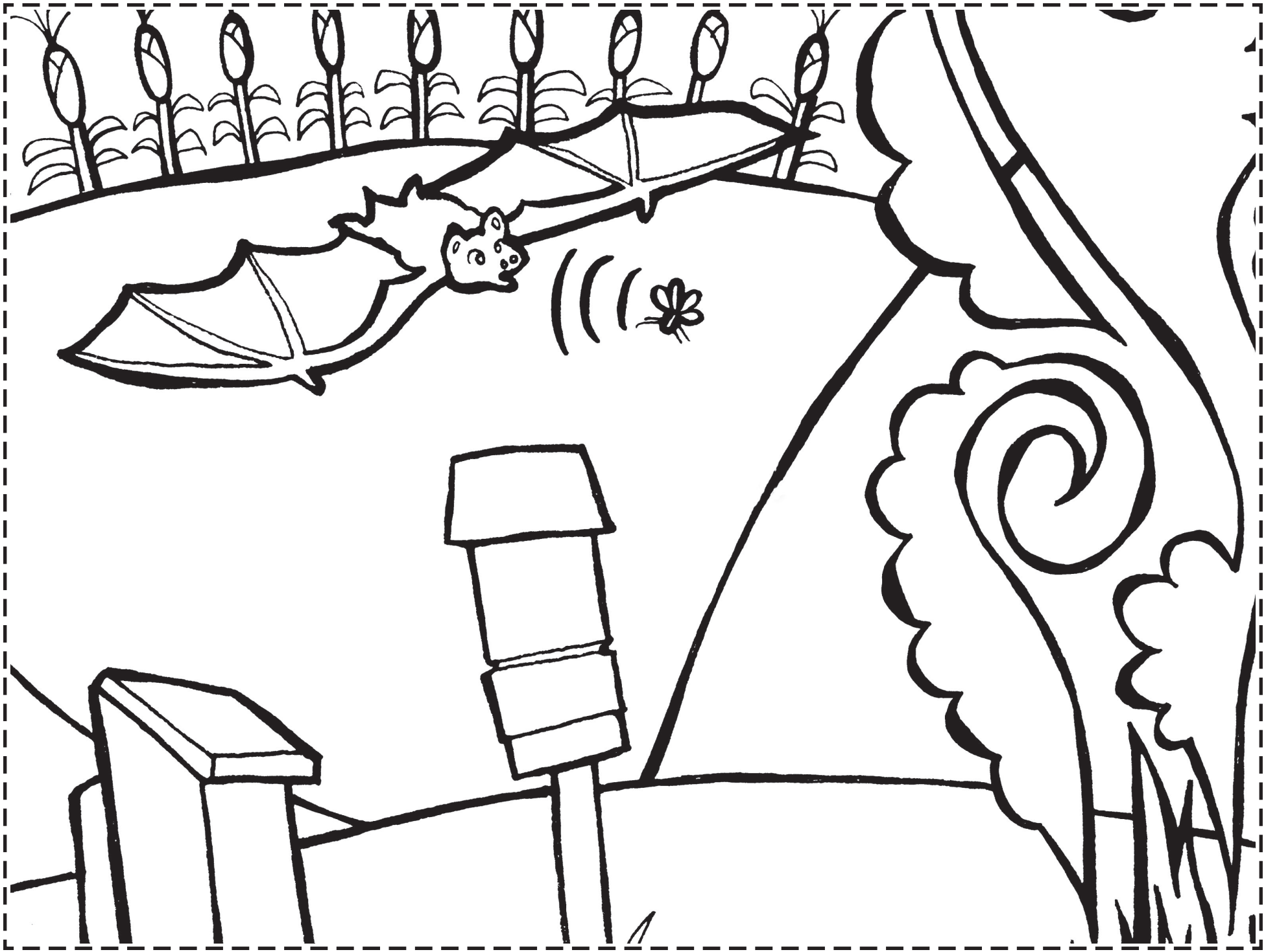


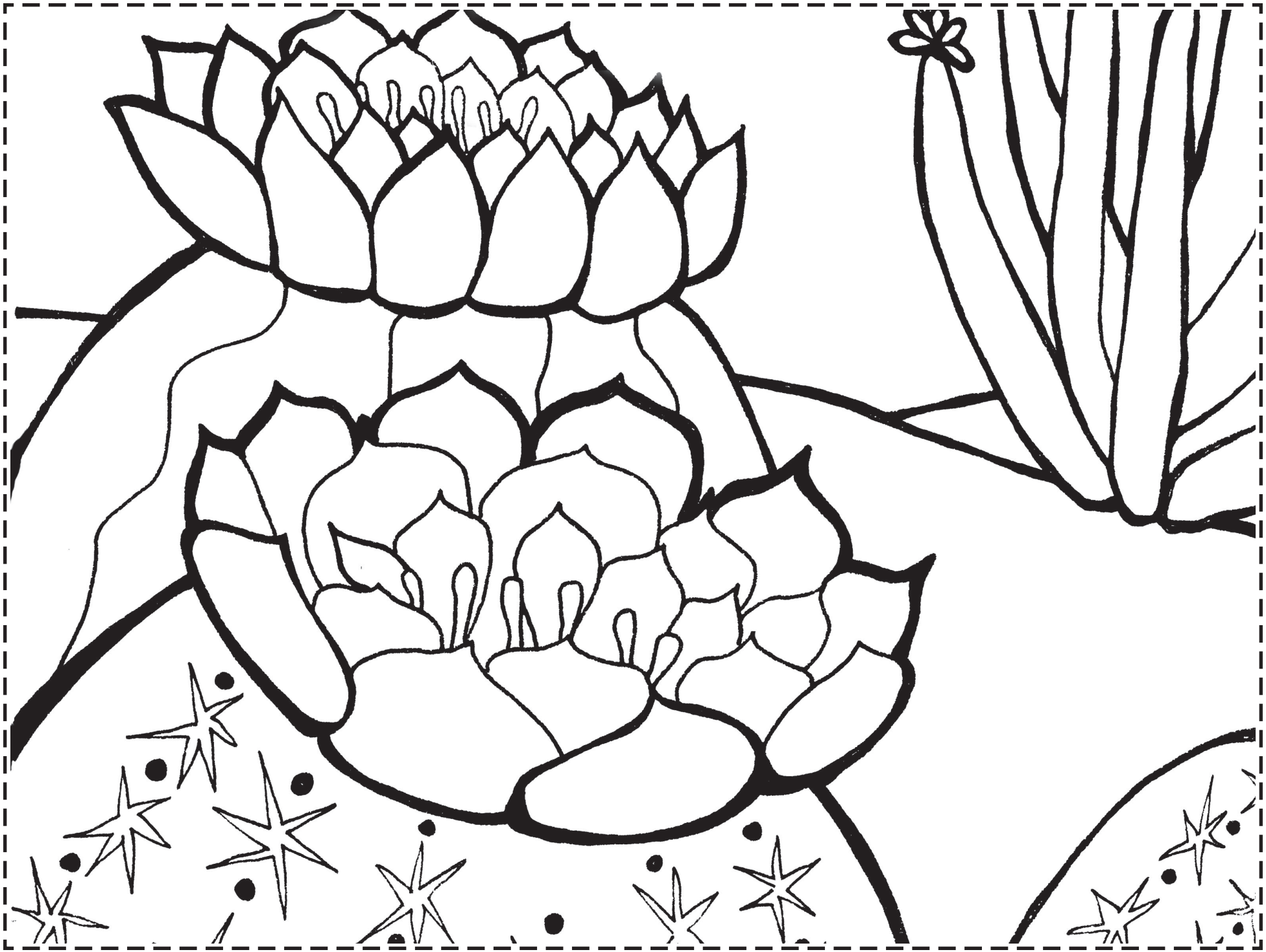


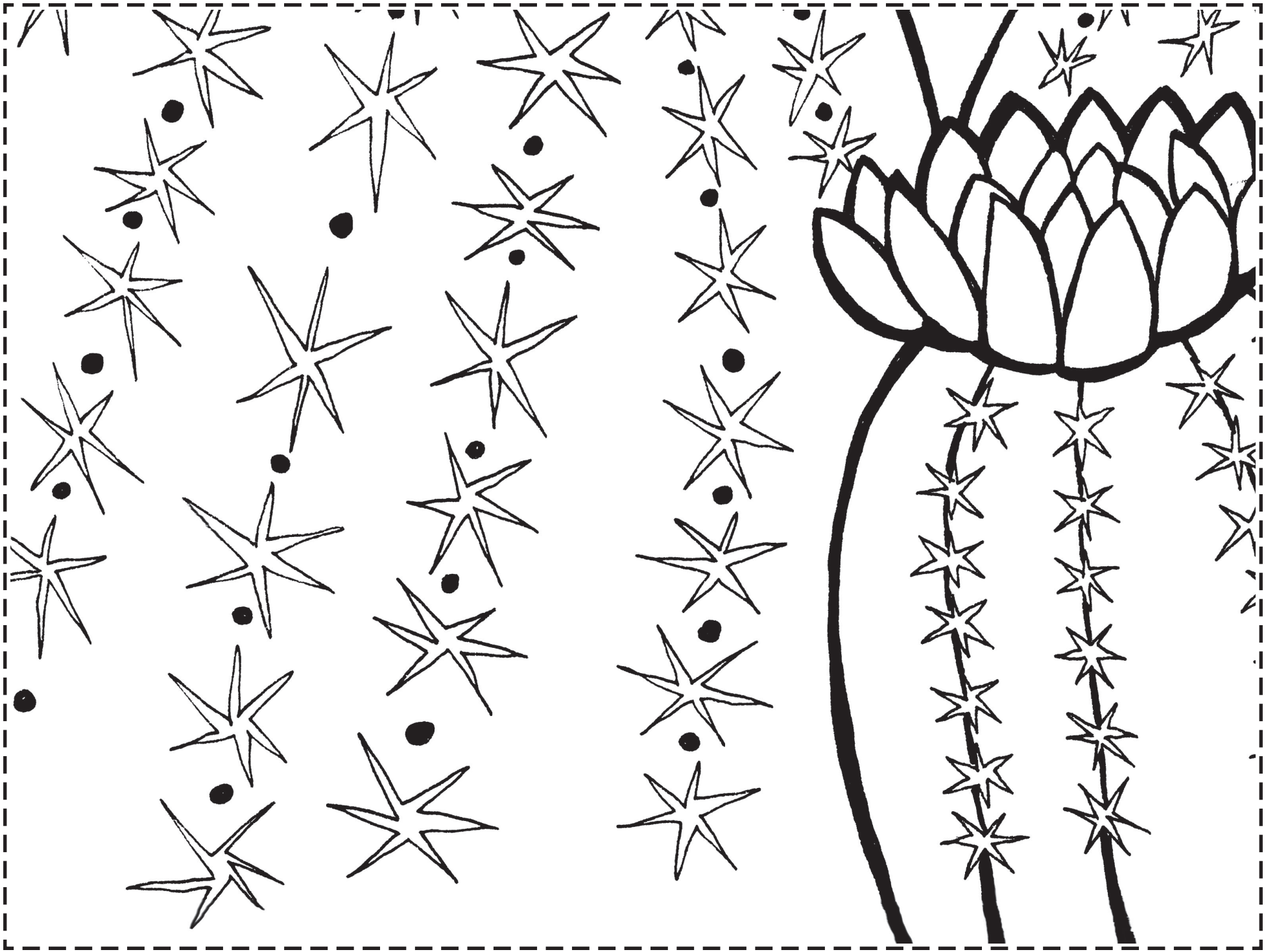


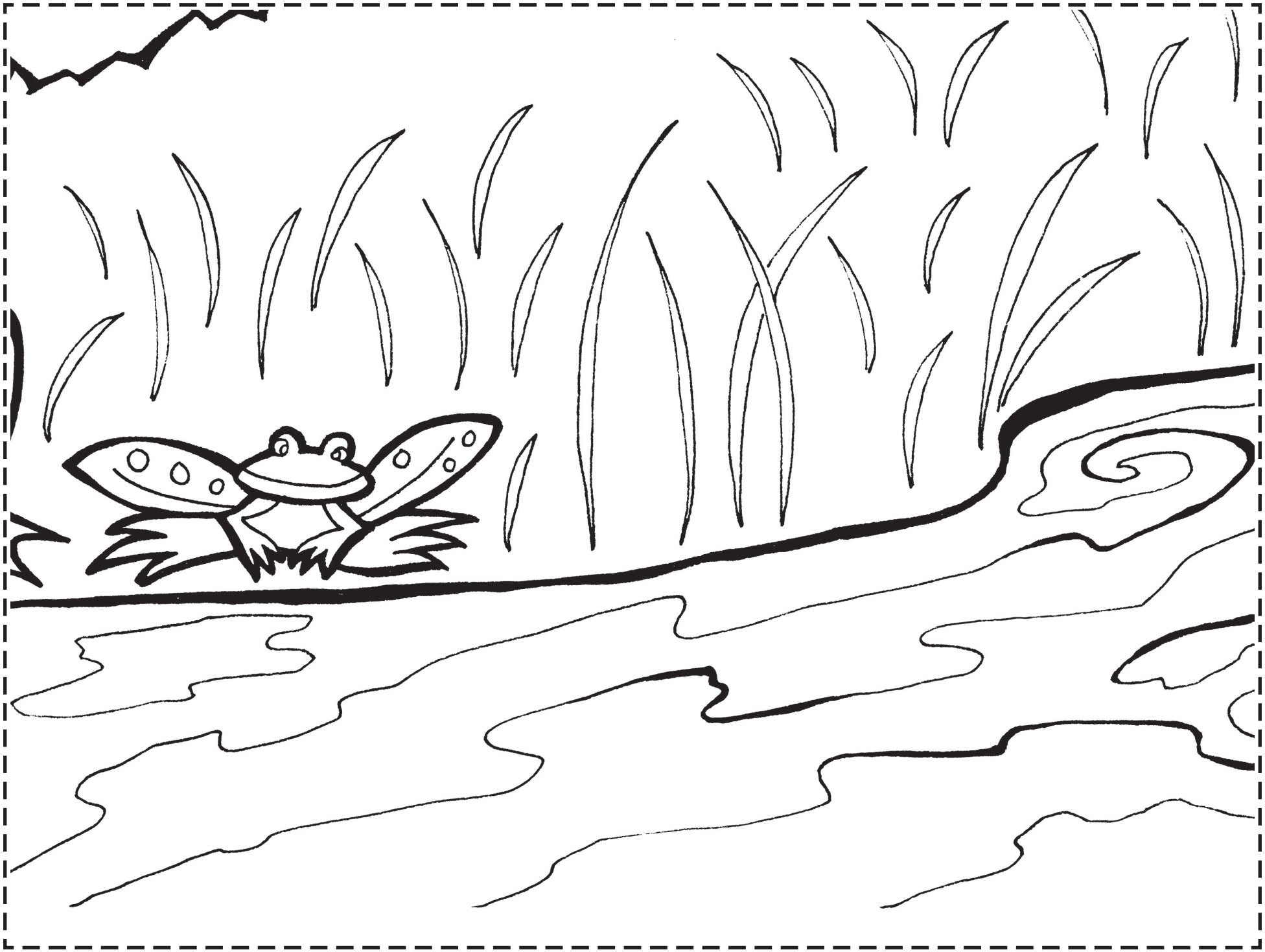


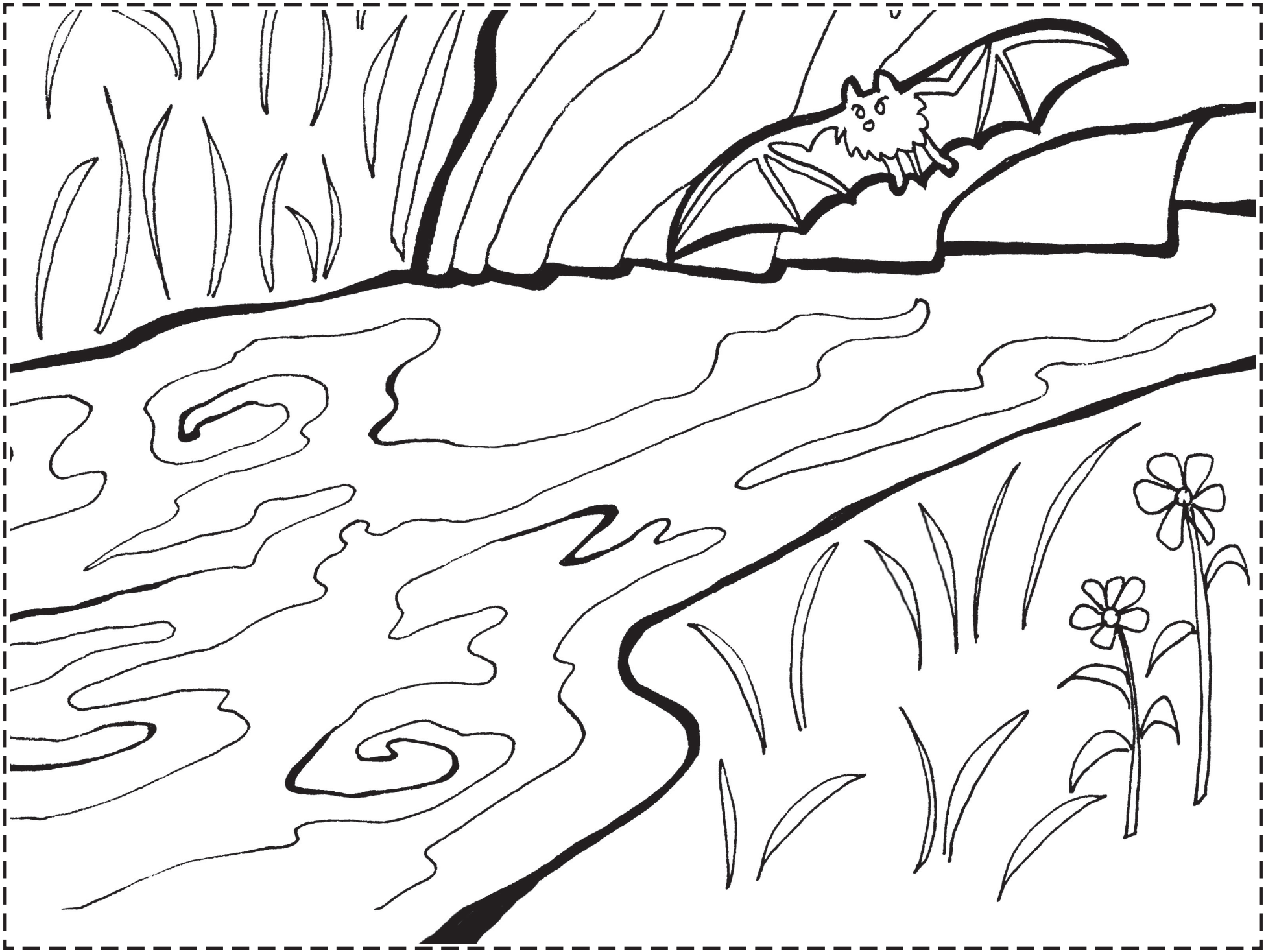












Additional Resources & Activities

Toilet Paper Tube Bat Craft

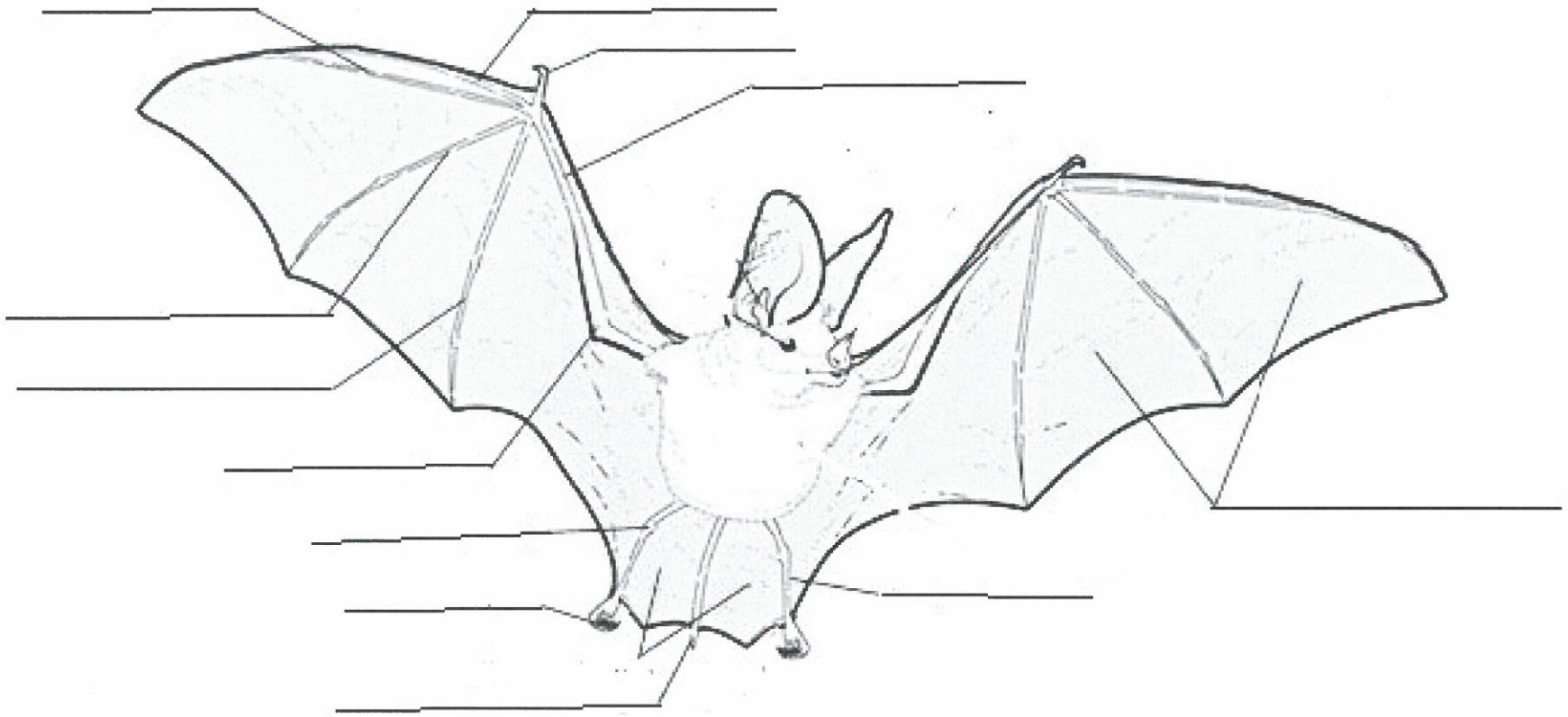
What you will need:

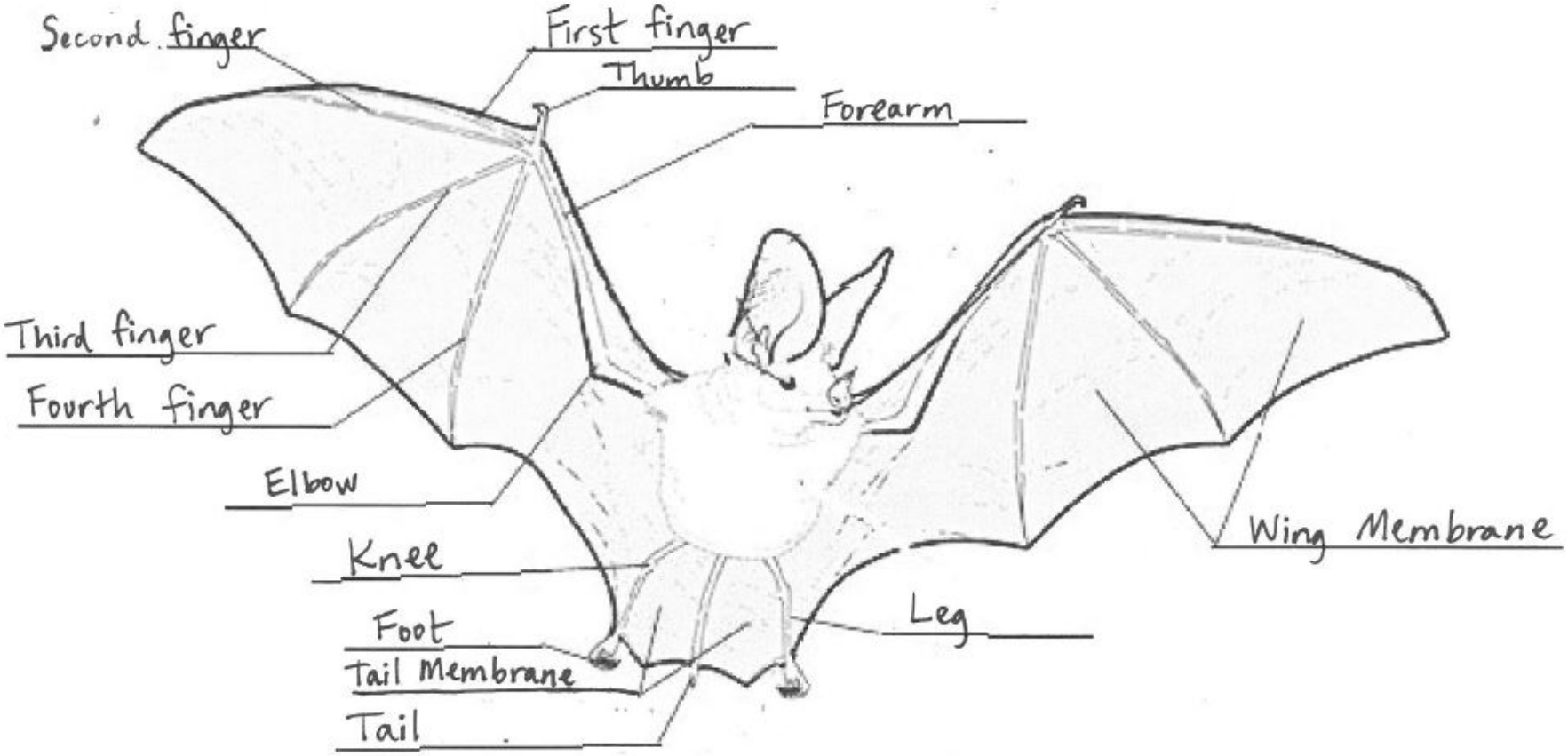
- A toilet paper tube
- A pipe cleaner
- Construction paper
- Scissors
- A pencil
- Crayons or markers
- A glue stick
- A hole punch

How to:

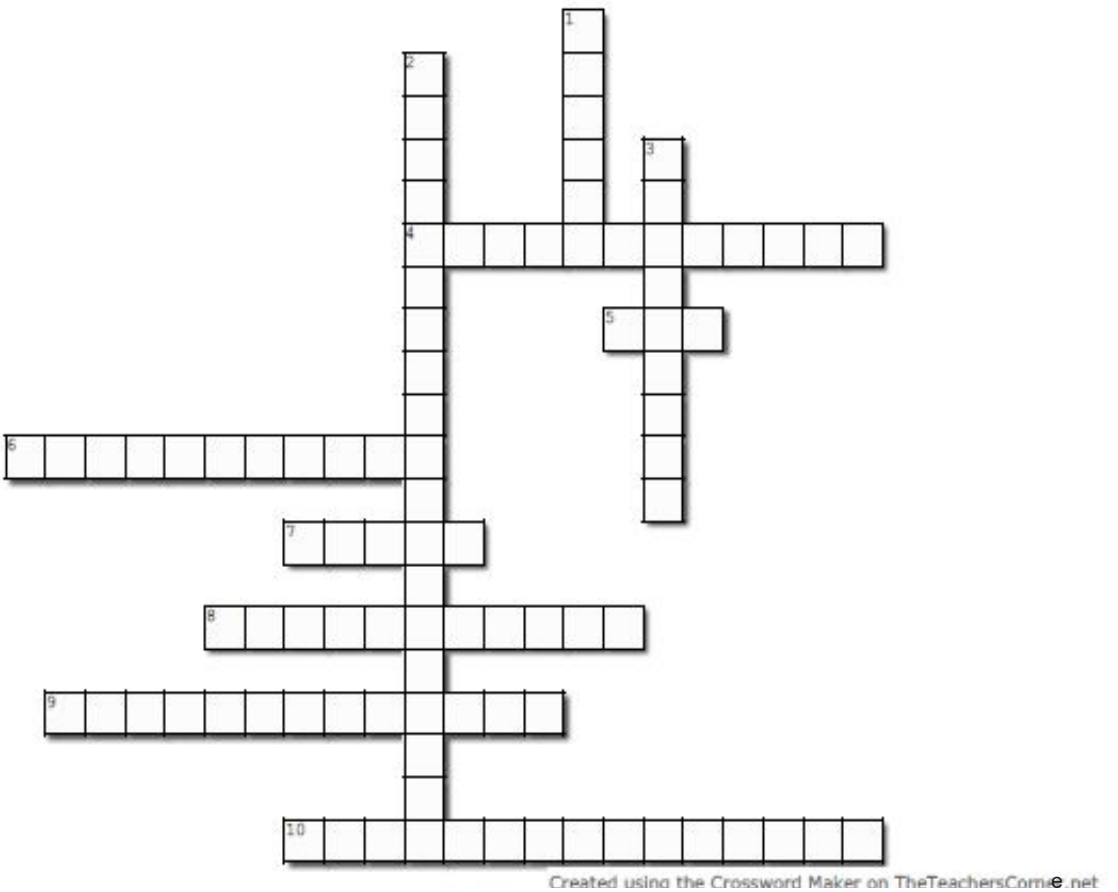
Punch two holes at the bottom of the toilet paper tube and fold the top half to make ears. Cut the pipe cleaner in half to make the legs, and feed them through the holes to make feet. Use a pencil to trace wings on a piece of construction paper. You can use your hand (fingers closed) as a guide, or can draw your own wing outline. Cut out the wings, and glue them on the back of the toilet paper tube. Add eyes, nose, mouth, and teeth, and you have yourself a bat!

DEM RHODE ISLAND




Second finger
First finger
Thumb
Forearm
Third finger
Fourth finger
Elbow
Knee
Foot
Tail Membrane
Tail
Leg
Wing Membrane

Bat Crossword Puzzle



See if you can solve this batty puzzle!

Across

4. When an animal makes a sound, and listens for how that sound bounces off an object; how bats sense the world around them
5. A baby bat
6. An animal that primarily eats insects
7. A place where bats gather to rest
8. Places where bats spend the winter to hibernate (caves, mines, buildings)
9. The skin that is stretched between a bat's fingers, allowing it to fly
10. A place where female bats of some species gather each year to birth and raise their pups

Down

1. An animal that has fur, gives birth to live young, feeds its young with milk, and is warm blooded
2. A fungal disease found in damp caves where bats hibernate in northeastern North America
3. Active at night

Bat Crossword Puzzle Answer Key

Across

4. Echolocation
5. Pup
6. Insectivore
7. Roost
8. Hibernacula
9. Wing membrane
10. Maternal colony

Down

1. Mammal
2. White-Nose Syndrome
3. Nocturnal

Bat Word Search

Q R G D N L Z D O V W T J I Z U T S P M A I A U M
J A O J W Y W R Q X H E B N I B J E Y S A L D A Z
M P J B I A H Q N O I T A C O L O H C E U M T P G
R Q L M A M K N K C T J I F L M A I V C K E M C N
Z Y Y E Y P J Z P E E U R H Y C Y J A H R R P A H
D Z V S X B S X R O N X S N M D J N B N W O D D L
O B P O Y K N J E X O A N B B L R V A S W V B C R
S N X Z W D B S I X S L R T V E T L B S X I E G B
G A G U M Q W U W C E Q F B B R C W Z H I T P R U
Y G G C Q P H F C L S K V I M O N J H T H C R O R
N J U U J K X T R A Y T H O L E J Z C B Q E F O O
N O C T U R N A L I N A P O X G M T D H I S D S N
Z U H U H W I F Q J D N N P W R U G R D M N N T W
O O P D M X P H U W R Y J K Q C S M N P G I X N M
D V Z K M N C Y R S O J Z K P Y P N U I M W K R M
M V X T I W J P A D M T I R X J W P I S W A W Q Z
U D C X G E C W S X E O R B X R I M Q V C S Z C M
H G M X J C X G O U C Z Z C V D S T P W L T G H J
P Z G H Z T N A L R J C O S G N H Y S A L P O L R
Q J I K Q E U N N V M F K K A V B K L O J J E R Z
P I X O Q I S Z X A H J O C M U N P A P E R B W Q
W Y Z Y F J T A Z H N D K V R O U V G K Y X Z T N
Q M C B I R A A M N A Z Z X O M H Y S N B J O W T
H D J T A S K R M Z V T L X A R J J F P H N A L C
D I K Y C J O V N A D U S J P Z Q Q H B M B Z Y T

e

Can you find all of these batty words?

Echolocation
Roost
Wing Membrane
Maternal Colony
Mammal
Nocturnal
White-Nose Syndrome
Pup
Hibernacula
Insectivore

RHODY CRITTER KITS

DEM RHODE ISLAND

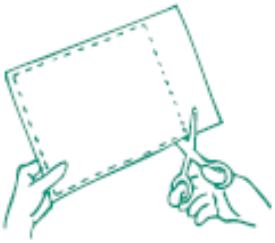
Fun Bat Facts at Your Fingertips!

Folding Instructions:

Make all folds neatly and squarely

1. Carefully cut along the dotted lines to make a square.

2. With the pictures and text facing upward, fold the paper neatly in half and then in half again.



3. Undo the folds and flatten out the paper. Flip the page over so that the blank side faces up. Fold in each corner so the four points meet in the center.

4. Flip the paper over. Again, fold in each corner so the four points meet in the center.

5. Fold the square in half, making a rectangle, with the open flaps facing down. The writing should be right-side up.

6. Slide both index fingers and thumbs under each of the four outer flaps.

7. Pinching your fingers together, push the top corners of the flaps toward the center. Poke down into the center to help form the shape.

To play the game:

1. Ask a friend one of the questions on any of the outer flaps.

2. Let them provide an answer or they can choose one of the possible answers on the inside flaps. By opening the game either one of two ways, four possible answers are revealed.

3. Once the correct answer is given, look under the selected flap to learn even more.

4. Ask each of the other questions and learn even more!

5. Place this fun game in your pocket and you will always have bat facts at your fingertips!

What dangers do bats face in the wild?

Insect Control

Bats eat tons of insects such as mosquitoes, beetles, moths, crickets, and much more! They help protect our farms, our forest, and our economy. Every year, bats save us **more than 23 billion dollars** in pest control by eating insects that could damage crops and forests. Bats are also important pollinators of many plants and trees including mangos, agave, and wild bananas.

Pollinators

What important roles do bats play in the environment?

A bat is a mammal!

Even though bats fly and people walk on the ground, bats and people are similar in many ways. That's because both people and bats are mammals. With few exceptions, all mammals give birth to live young, nurse babies with milk, and have hair. Other mammals include dogs, cats, chipmunks, raccoons, elephants, monkeys, and whales. One of the great things about bats is that they are the only mammal that can truly fly!

Bats make up what % of all mammals?

Habitat Loss & Disease

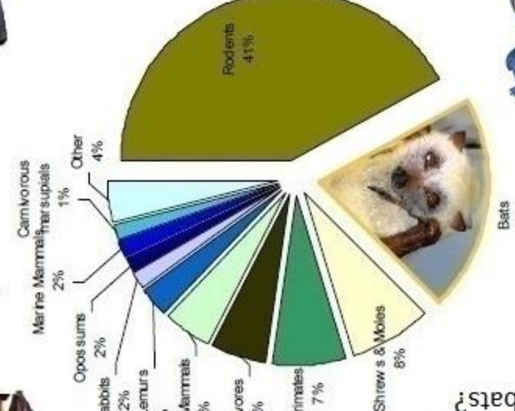
Bats are in decline nearly everywhere they are found. A new disease, White-Nose Syndrome has killed Over 6 million bats in 6 years in the U.S. and Canada!

Other dangers facing our bats are habitat loss, increased pesticide use, wind energy development, residential and industrial development, and even people harming bats because they don't understand their value. Bats need our help!

How could you help bats?

Are bats birds or mammals?

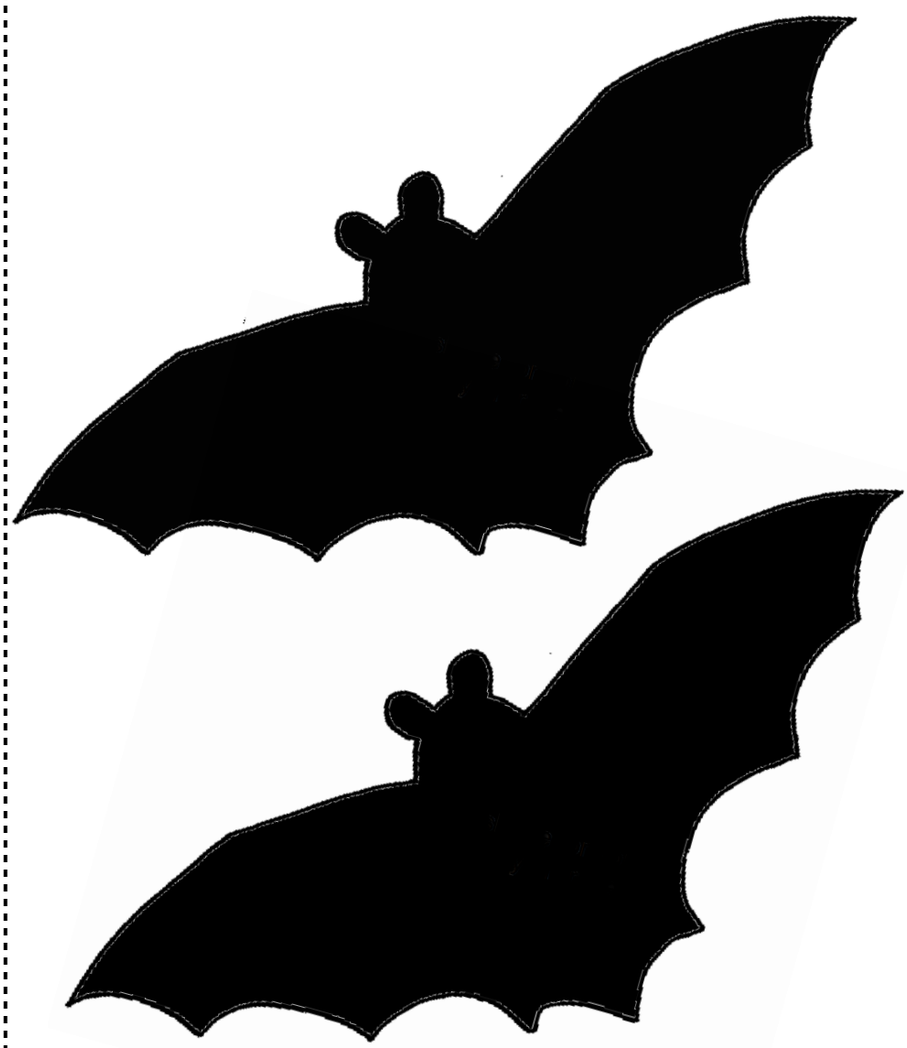
Bats make up one fifth of all mammals



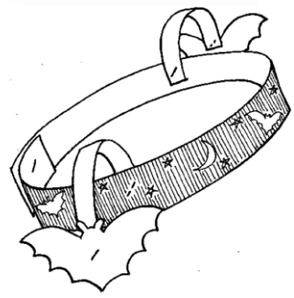
There are over 1300 species of bats.

BAT HATS

-have fun with your friends!



You will need:



- Scissors
- Tape
- Crayons
- Your imagination

1. Print the template on an 8.5” X 14” piece of cardstock
2. Cut out the 2 wide bands along the dotted line and tape them together to fit your head.
3. Add insects, plants, or anything cool to make your hat different and teach people about bats!
4. Cut out the bats and tape them to the end of each of the 2 shorter strips of paper. Then, tape the other end of the strip to the inside of your headband as shown in the picture above.

What did you do to make your hat unique? How does your hat tell people about bats?

Bat Hats were created by: Bat Conservation Trust