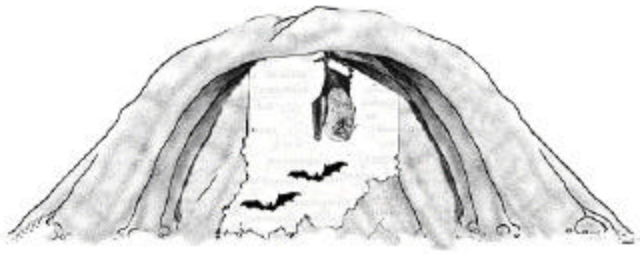
Indiana Bats, Kids & Caves - Oh My!

An Activity Book for Teachers

By
Diana M. Barber, Ph.D., Sarah D. Tye, & Leigh Ann O'Donnell

The Education Department of
Evansville's Mesker Park Zoo & Botanic Garden



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2421 Bement Avenue, Evansville, IN 47720

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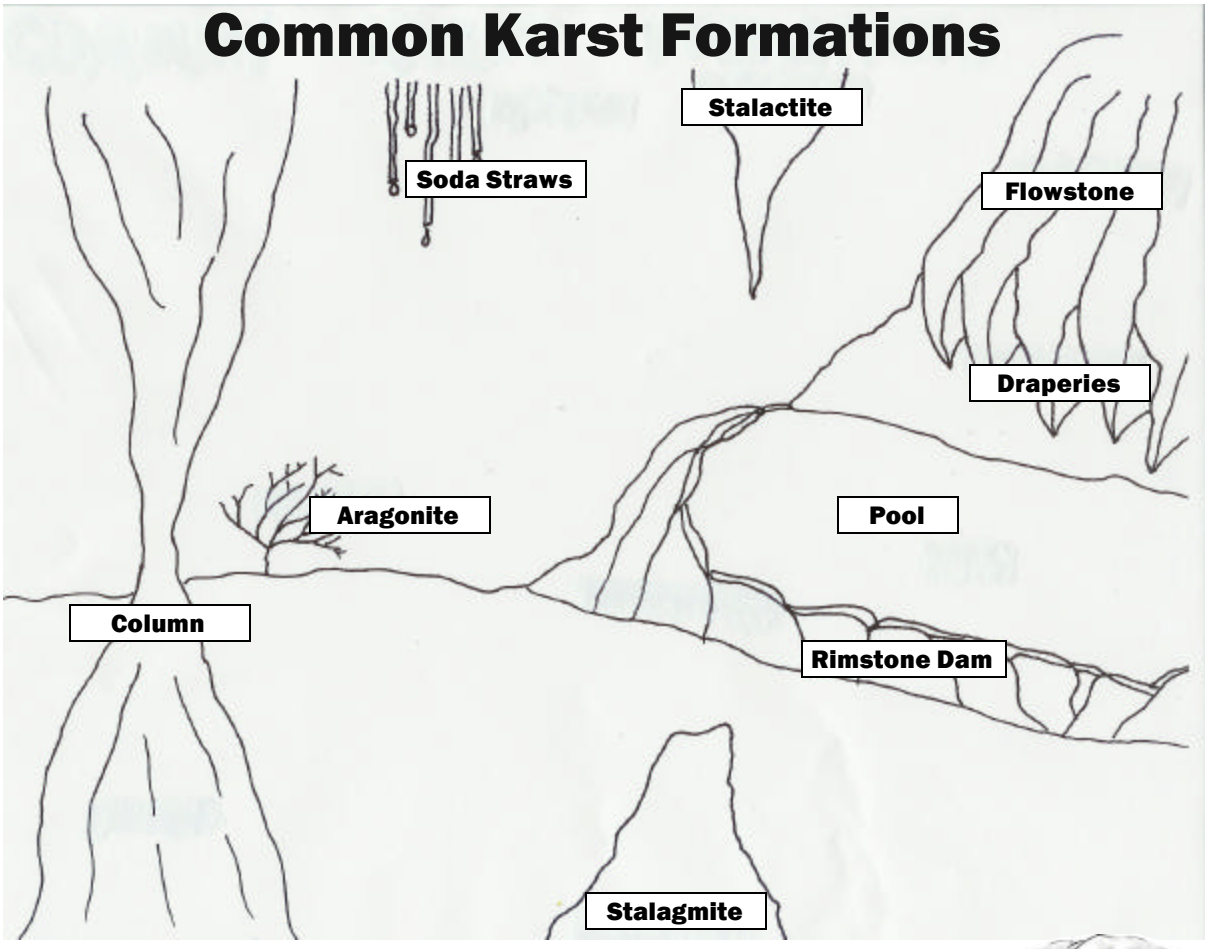
Karst for the Classroom

Bulletin Board Set-Up

Materials: Bulletin Board Paper (brown or gray) ● Construction Paper ● White Tag or White Construction Paper ● *Spelunker Speak* Vocabulary (see Activity 2)

Before starting the unit, prepare your room with this bulletin board to help teach students about cave formations.

The formations can be drawn and colored onto the bulletin board or made out of construction paper and added. All of the labels and letters should be done on separate paper and stapled on top, as they will be removed at the end of the unit so that the "cave" becomes the background for posting student stories (see Activity 19). See Activity 2, *Spelunker Speak*, for terms that can be illustrated.



2 Spelunker Speak

Cave Vocabulary

Materials: Vocabulary List ● Crossword Puzzle ● Pens and/or Pencils

Students should solve the crossword puzzle using words from the Cave Vocabulary list. These words can also be used for the bulletin board in Activity 1.

Answers:

Across

2. Calcite
4. Cave Coral
6. Karst
7. Speleothem
10. Shields
11. Stalagmite
12. Rimstone Dams
14. Stalactite

Down

1. Flowstone
2. Column
3. Drapery
5. Aragonite
8. Helictites
9. Soda Straws
13. Spelunker

Name _____

2 Spelunker Speak

Words every spelunker should know...

Aragonite	A cave mineral, which often forms needle-like crystals.
Calcite	A common crystalline form of calcium carbonate.
Cave coral	Also known as “popcorn”; small knobby clusters formed by seeping water.
Column	When a stalactite and a stalagmite grow together from the floor to the ceiling.
Drapery	A speleothem formed when water deposits calcite in thin sheets that hang in delicate folds.
Flowstone	Resembling frozen waterfalls, form when water flows down walls, over floors and older formations, building up sheets of calcite like icing on a cake.
Helicitites	Small twisted structures projecting from ceilings, walls and the floor of caves that seem to defy the laws of gravity. Formed by seeping water, they project at all angles.
Karst	An irregular limestone region with sinks, underground streams, and caverns.
Rimstone dams	Step-like terraces along streams and on cave floors that enclose pools of water.
Shields	Flat semi-circular calcite sheets formed by water seeping from a thin crack.
Soda straws	Thin hollow tubes that grow from the ceiling of caves as water runs down inside them and deposits rings of calcite at their tips.
Speleothem	Any mineral deposit or formation found in caves.
Spelunker	A person whose hobby is exploring caves.
Stalactite	An icicle-like deposit that grows down from the cave ceiling.
Stalagmite	Speleothems that grow up from the floor.

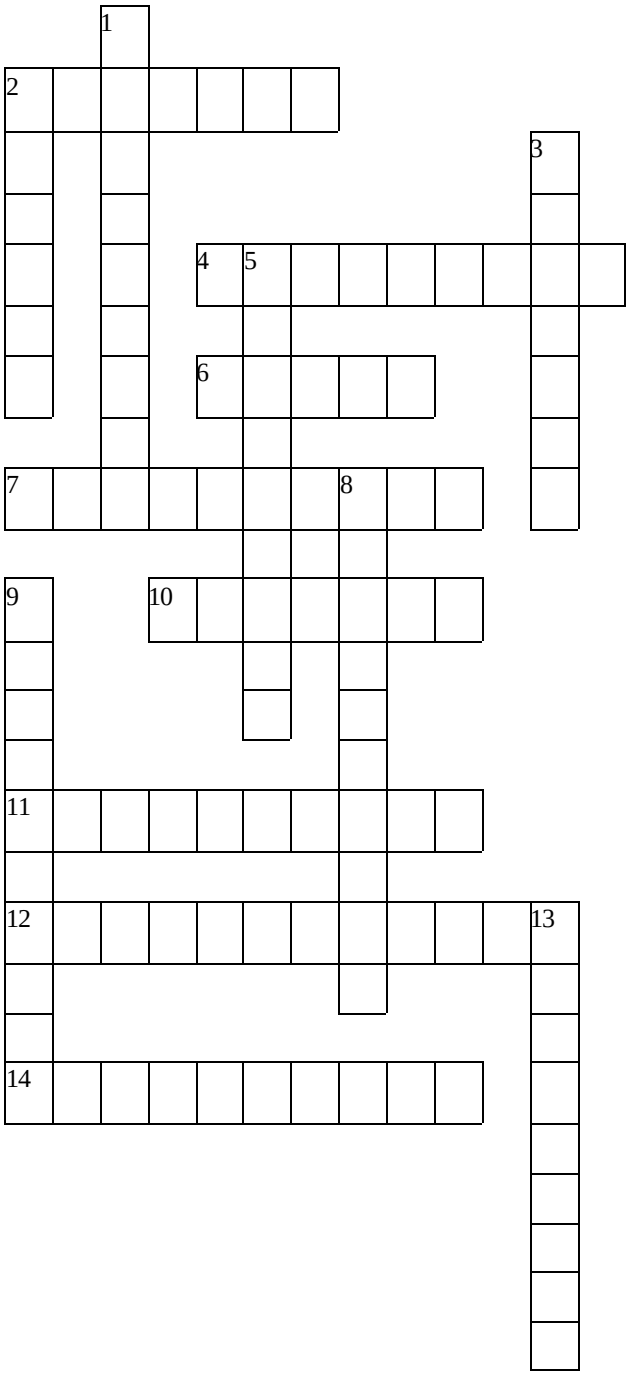
Name _____

2 Spelunker Speak

ACROSS

2. A common crystalline form of calcium carbonate.

4. Also known as "popcorn"; small knobby clusters formed by seeping water.



6. An irregular limestone region with sinks, underground streams and caverns.

7. Any mineral deposit or formation found in caves.

10. Flat semi-circular calcite sheets formed by water seeping from a thin crack.

11. Speleothems that grow up from the floor.

12. Step-like terraces along streams and on cave floors that enclose pools of water.

14. An icicle-like deposit that grows down from the cave ceiling.

DOWN

1. Resembling frozen waterfalls, form when water flows down walls, over floors and older formations building up sheets of calcite like icing on a cake.

2. When a stalactite and a stalagmite grow together from the floor to the ceiling.

3. A speleothem formed when water deposits calcite in thin sheets that hang in delicate folds.

5. A cave mineral that often forms needle-like crystals.

8. Small twisted structures projecting from ceilings, walls and the floor of caves that seem to defy the laws of gravity. Formed by seeping water, they project at all angles.

9. Thin hollow tubes that grow from the ceiling of caves as water runs down inside them and deposits rings of calcite at their tips.

13. A person whose hobby is exploring caves.

Sanctuary of Stone

Reading Comprehension

Materials: Sanctuary of Stone story ● Comprehension Worksheet

Unit vocabulary words, as well as words students may not know, are bolded in the story.

Answer Key

Comprehension Worksheet

1. Who (or what) is the narrator of the story? What clues in the story tell you this?
*The cave. Clues include **my** walls, **my** stalactites, **my** front rooms, etc.*

2. Besides humans, what creatures use the cave?
Bats, insects and blind cavefish.

3. In the second sentence, who are the "first people"? What does the narrator mean when he (or she) says "they came to paint their dreams on my walls?"
The first people are Native Americans who painted animals and spiritual symbols on the cave's walls.

4. How are bats important in the story?
The bats make the narrator happy, and he/she measures time by the comings and goings of the bats. The bats are an important part of the cave ecosystem.

5. What is the narrator's relationship to the bats? Does it change?
The narrator sings in harmony with the bats; they are almost part of his/her "body." The narrator weeps for the sufferings of the bats, but cannot help them. The narrator's relationship to the bats does not change; he/she hurts when they are hurt and rejoices when they are happy.

6. List three ways people used the cave in recent times.
To "drink and party" during Prohibition; for cruel entertainment (the boys shooting and burning the bats); for scientific study; and for tourism.

7. What impact did human activity have on the bats?
Mostly negative, until recently. The partiers and the young men and boys killed the bats for entertainment, or because they considered them a nuisance. Also, human disturbance caused the bats to wake up from hibernation and starve. Populations in the cave declined, then rebounded somewhat, and have stabilized recently with the coming of environmentally-conscious tourists who try not to disturb the bats, and scientists who try to protect the bats by studying their habits and installing gates.

8. How does the narrator's impression of people change over time?
Throughout most of the story, the narrator believes people are evil, since they kill bats and have no respect for nature or appreciation for the cave ("they look without seeing"). However, once scientists and environmentally-conscious tourists begin coming, the narrator warms up to them since they try not to disturb the bats and appreciate the beauty of the cave. The cave has even started a few patches of special speleothems for the tourists, and thinks some day he/she may sing with the humans like he/she now sings with the bats.

Sanctuary of Stone

By Diana M. Barber, Ph.D.
Illustrations by Kaitlyn Tye

For as long as I can remember I measured time by the comings and goings of bats. Even after the first people came to paint their dreams on my walls, the great autumn swarms of bats were my best timekeepers. My **stalactites** dripped and my **stalagmites** grew year round. Insects and their **predators** constantly scurried over the great piles of **guano** left by my summer **tenants**. One of my front rooms even housed strange little fish, white and sightless. Their entire **ecosystem** was based on the summer clouds of bat mothers and their babies. But the summer bats didn't keep the years for me and they never came down to visit my **cathedral.**

In my cool depths I didn't notice the **frigid** winds or hot summer nights. It was constant, stable, safe. The **vaulted** ceilings of my cathedral were quiet and lifeless in summer. I had only my sighs and shifting air to make the crystal **speleothems** hum. I knew a year had passed when the great choruses of bats returned to the cathedral. The crystals hummed at higher **frequencies** and the bats and I would **harmonize**. When the great hall's ceiling was completely filled with patches and drifts of bats swaying and shifting, I would breathe a sigh of contentment. It would start to grow quieter, their wings would gently whisper, and the bats would start their great sleep. I don't know if they **meditated** or dreamt, but I snuggled happily under the soft furry blanket of their bodies and wished for a long winter.

I had crafted the great crystal sculptures for the amusement of my silken flyers and the beauty of their songs. How could I have known that a new people would come? They were as pale as the cavefish and they looked without seeing. At first, it was just simple explorers and adventurers fascinated by the complex world beneath their feet. Then more people came with smoking lanterns and declared ownership of the cathedral the water and I had not built for them. Little did I know there

was worse ahead.

Several autumns passed and the bats slept fitfully. They survived, but the humans changed the temperature and humidity of the cathedral just by their presence. Then the men in shiny cars, the fast talkers, came with hordes of men. They cursed every slippery step into my depths and set up great lines of men to bring in tables, chairs, gas lights, and crates and crates of liquor. Every day men with rifles came and **massacred** my winter friends in their sleep. Some escaped, but the **corpses** of my gentle friends were swept into great piles and carted off in the empty liquor crates. Then at night the humans would sing, smoke cigarettes, and shout at each other. My crystals shrieked and cracked under the strain. Delicate structures were knocked off or melted away in the heat and smoke and noise. The bats were warmed in the winter and many starved before they woke or woke early to take their chances away from the world of men.

As bad as the shooters and partiers were, I still had not seen the worst of men. Many winters after the drinking parties stopped coming, my friends started returning to the cathedral. Much fewer bats than before, but my stable temperatures and constant humidity helped them to survive and begin to recover. Unfortunately, the cathedral was still not safe. The young men and boys shattered my quiet **sanctuaries** with gunpowder and fire. Armed with flashlights they roamed my passages, destroying art it had taken me centuries to grow. I whispered warnings to my sleepers in the winter, but they could not escape. The boys sprayed kerosene on their soft, gentle bodies and lit them on fire. My walls streamed with tears, but I could do nothing. I watched my friends, a **matriarch** of 20 + years, a juvenile seeing his first winter, the sisters with such sweet voices, all screaming in agony.

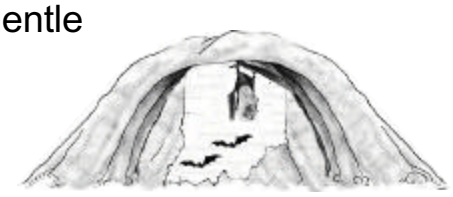
The bats fled my cathedral. Its vaulted ceilings were empty of my swift friends. No more did their high delicate voices harmonize with my deep sighs and bring our crystals to life. I sang, but I sang alone. I wept, but my walls wept alone. I could hear them occasionally in a distant small cavern unknown to man, but the great swarms were gone. I lost track of time for a while. I don't know how many winters I spent alone wishing for the soft swish of my friends' return. I longed for them to close their bright eyes, wrap their wings around

themselves and sleep their winter woes away with me, safe again in my cathedral.

Perhaps they missed me, too. I ached with joy when the first hesitant calls bounced off my cathedral's crystal-encrusted walls and made my caverns sing. The bats returned in small parties at first. Several winters came and went and the patches of bats on my ceiling began to grow again. I wondered if I would ever see the great swarms again. If my cathedral would ever fill again to **capacity**, and life would be as it was.

Humans came throughout the year and many of my friends woke too early as a result of the humans' winter visits. It was about twenty summers ago that a different sort of human came to visit. They carried clipboards and other strange instruments, but walked carefully and took only pictures. A short time later, maybe a year or two, there was a strange hammering and drilling coming from my entrances. Great gates of metal spanned the openings with gaps big enough for the bats to fly through, and only one door for people. When autumn came, the bats returned, buzzing amongst themselves about the new structure at the entry. I fretted about this new structure all winter while my charges slept their deep sleep. For the first time in decades, no humans disturbed their slumber and most of the bats made it through alive.

Now I tell time differently than I used to. I still track the comings and goings of bats and delight in the arrival of the autumn swarms. But I have new visitors, careful visitors. They come in the late spring and summer when the bats have gone. Some of the humans have been coming so often that I begin to recognize their voices. They lead groups of strangers through my passages and protect me from their clumsy feet. Sometimes when it's quiet, I think my new friends can hear me whisper in their ears. I have started a few patches of special **speleothems** for these humans and soon I think we'll sing together too. Until then, I will live in harmony with these humans, but hum with joy when my soft and gentle flyers sing with me in our sanctuary of stone.



Name _____

Comprehension Worksheet for Sanctuary of Stone

1. Who (or what) is the narrator of the story? What clues in the story tell you this?

2. Besides humans, what creatures use the cave?

3. In the second sentence, who are the "first people"? What does the narrator mean when he (or she) says "they came to paint their dreams on my walls?"

4. How are bats important in the story?

5. What is the narrator's relationship to the bats? Does it change?

6. List three ways people used the cave in recent times.

7. What impact did human activity have on the bats?

8. How does the narrator's impression of people change over time?

Caves & Bats in Indiana

Mapping Activity

Materials: Bat decals ● Indiana County Map (enlarged to 8.5 x 14) ● Indiana Karst Map (enlarged to 8.5 x 14) ● Tissue Paper ● Bat Hibernacula chart ● Markers, crayons, &/or colored pencils ● Glue

Challenge students to consult road maps and/or the Internet to see if they can locate five commercial cave sites in Indiana. What do they notice about the distribution of these?

The five cave sites are:

- Bluespring Caverns (Lawrence County)
- Spring Mill State Park Caves (Lawrence County)
- Marengo Cave (Crawford County)
- Wyandotte Caves (Crawford County)
- Squire Boone Caverns (Harrison County)

Copy the Bat Decals and the "Caves & Indiana Bat Hibernacula by County" chart, one for each group. Enlarge the Indiana County map to at least 8 ½ x 14" and make a copy for each group. Enlarge the Indiana Karst Map by the same amount as the County Map and give one to each group along with tissue paper OR enlarge the Karst Map (map portion only) onto a transparency for each group, in addition to giving them a regular copy of the Karst Map. When enlarging maps, make sure to enlarge both by the same amount so they will line up when stacked together.

Using the chart "Caves & Indiana Bat Hibernacula in Indiana by County," and the large county map of Indiana, have students (working in groups):

- Develop a color key to plot caves by county and color the map accordingly
- Choose a different color for each priority level and have the students write the class's color choices in the space provided. Do not choose the same colors that were selected to indicate the locations of caves. The students should color code the bat decals accordingly.
- On the map where students have plotted caves, have them glue the bat decals provided to indicate locations of Indiana Bat hibernacula.
- Optional: Have the students make a key to the priority level of the hibernacula on the map sheet.
- Discuss patterns. Are caves/hibernacula distributed evenly throughout the state? Have students predict some reasons for the distribution they see.
- Copy the Indiana karst area map onto a transparency for each group OR have each group trace it onto tissue paper. Lay the transparency/tissue over the colored/keyed map.
- Discuss with students: what is the relationship between Indiana karst areas and the distribution of caves/hibernacula? What is *karst* anyway?

Name _____

Caves and Indiana Bat Hibernacula in Indiana by County

		HIBERNACULA*			
County	**Number of Caves**	**Priority 1**	**Priority 2**	**Priority 3**	**Priority 4**
Bartholomew	10				
Brown	1				
Clark	63				
Clay	1				
Crawford	218	2		3	1
Decatur	19				
Delaware	3				
Dubois	13				
Floyd	5				
Fountain	2				
Greene	60	1		1	3
Harrison	632	2	2	2	
Jackson	4				
Jefferson	157				
Jennings	191				
Lawrence	490				5
Martin	124			1	1
Monroe	267	2		5	2
Morgan	12				
Orange	292				1
Owen	94				
Parke	2				
Perry	9				
Putnam	18				
Ripley	32				
Scott	1				
Shelby	5				
Tippecanoe	8				
Vanderburgh	4				
Wabash	4				
Washington	162		1	2	
TOTAL INDIANA CAVES	2902				
TOTAL (KNOWN) INDIANA HIBERNACULA		7	3	14	13

*Priority	Current &/or Historic Population
1	More than 10,000 Indiana bats
2	1,000 - 10,000 Indiana bats
3	50 - 1,000 Indiana bats
4	Less than 50 Indiana bats

Name _____

Bat Decals

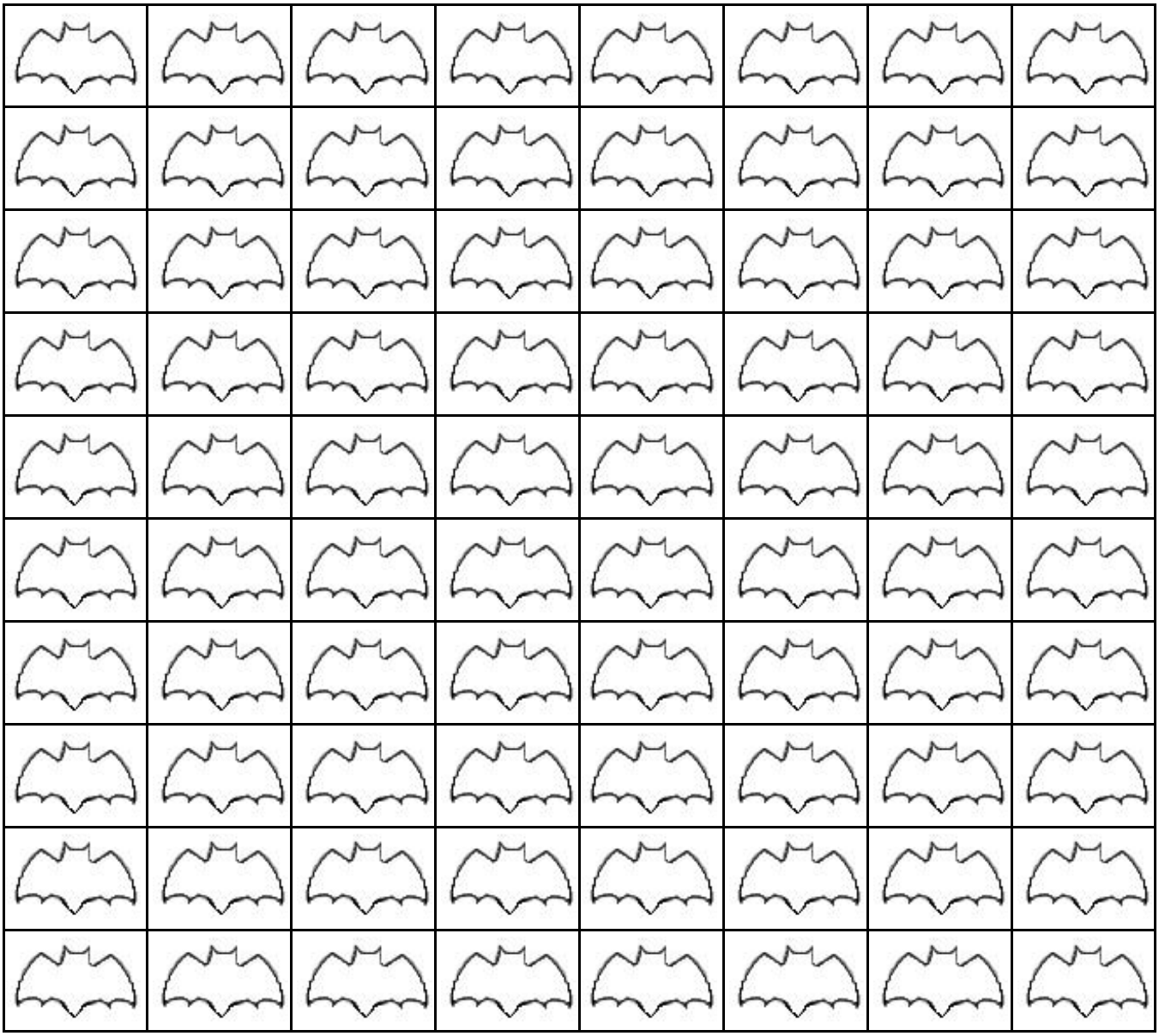
Color Code for Bat Decals:

Priority 1 Hibernacula _____

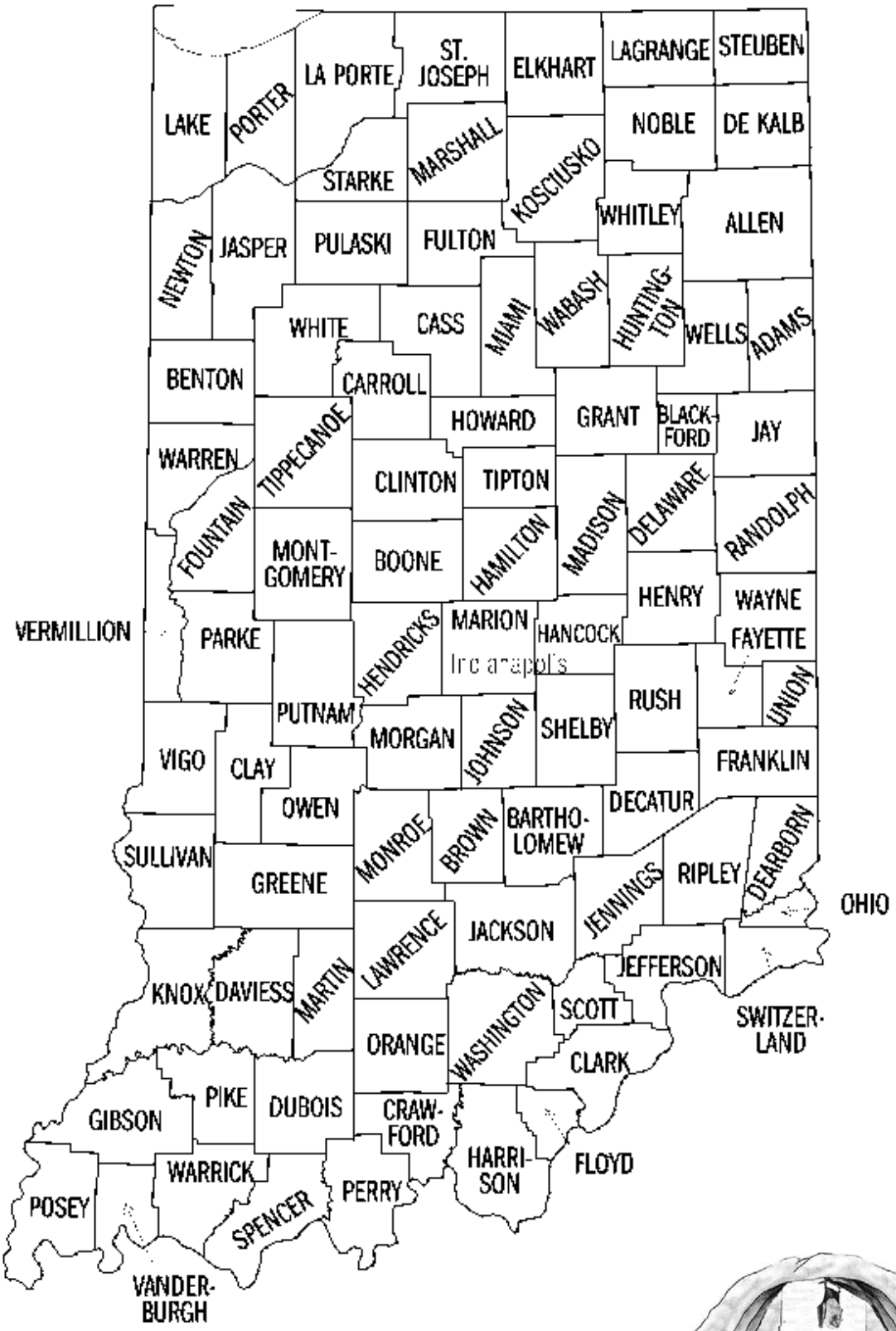
Priority 2 Hibernacula _____

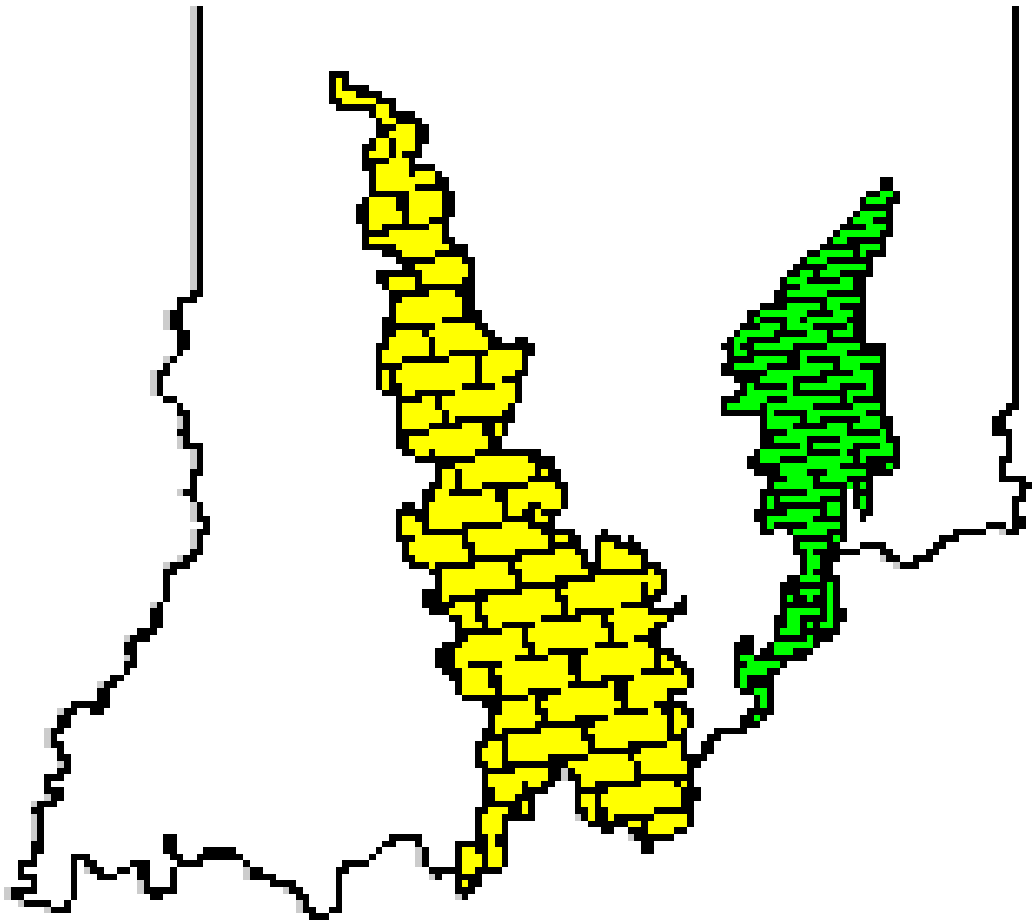
Priority 3 Hibernacula _____

Priority 4 Hibernacula _____



Indiana County Map





Major Karst Regions in Indiana

1. Mitchell Plateau (Mississippian Limestone): extends from eastern Owen County in the north to the Ohio River in Harrison County on the south.

2. Muscatatuck Plateau (Silurian & Devonian Limestone): in southeastern Indiana, from the Ohio River in Clark County in the south to Decatur County in the north.

5 In The Caves Where We Live

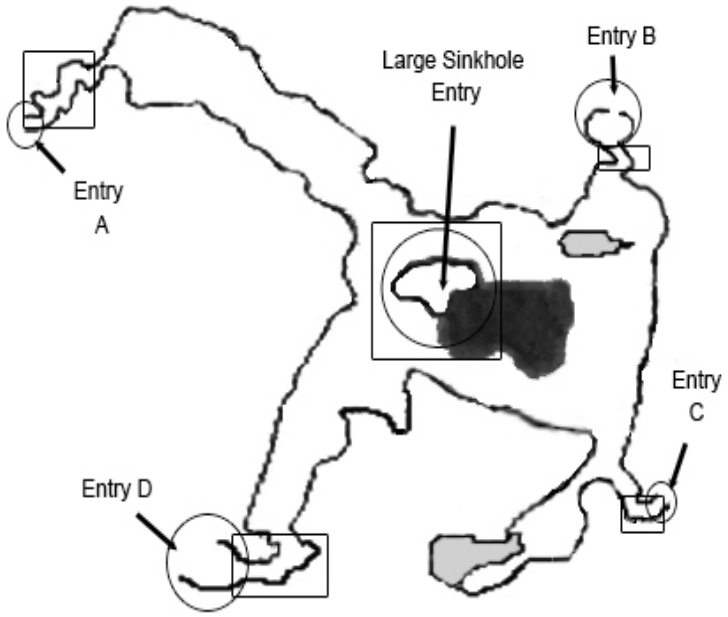
Cave Communities

Materials: Cave Communities reading (pg. 5-3 and 5-4) ● Worksheet (pg. 5-5 and 5-6)

Students should read the descriptions of cave communities and answer the related questions.

Key:

1. Approximate locations of the Entry zones are indicated with ellipses, the Twilight zones are contained in rectangles. Everything else is the dark zone.



2. The cave community would be much more complex in the area where the bats roost. Decomposers would use bat guano as an energy source.
3. Since the colony is in the dark zone, some members of the community may be blind, white/pink or have long antennas.
4. Since the bats provided the energy source, following the cave-in, the terrestrial community would become less complex and might disappear.
5. The aquatic community may become less complex, but as long as resources continue to be brought in by the stream it will survive.

6. In what zone or zones would you find:
    a. Dark Salamanders – adults throughout the cave – juveniles in the water in the dark zone
    b. Walking Ferns – mostly in the entry, very few in the twilight zone
    c. Cave Crayfish – twilight zone
    d. Nesting Birds – Entry and twilight zone
    e. Pill Bugs—Entry and twilight zone

Name _____

In The Caves Where We Live

Read the following descriptions of various cave communities and answer the questions on page 5-5 and 5-6.

You might be surprised by how much life is below the surface in a cave. Cave communities depend on energy brought in from the surface world. You can predict what kind of organisms will be in a community based up on where in the cave they live.

Entry

Entries can be natural or man-made and vary in size. Cave entries can range in size from thin crevices in a rock face to caverns large enough to fit several vehicles. Sinkholes provide vertical entries into caves. The most diverse communities within a cave are found in large entries. If an entry is big enough then enough sunlight will reach within the cave to support plants. They are not specially adapted to cave life and green algae and woodland plants like mosses and ferns are most common. These species are able to tolerate the low light levels that at the cave mouth. Leaves and other plant litter blows in from plants outside the cave and support decomposers. Many of these decomposers are also found outside of caves, such as small millipedes, terrestrial isopods (also known as pill bugs or roly-polies), terrestrial snails, earthworms, cave crickets, and other insects. Several species of flies, gnats and midges feast on the organisms and waste found in the entry. Centipedes and a variety of salamander species hunt the decomposers and the flying insects and may venture outside the cave to pursue other meals.

Larger animals use the cave entries for shelter for themselves or their young. Frogs and snakes take advantage of the stable temperatures with in the cave for thermoregulation and hibernation in winter. Snakes may also use the cave entry to hunt birds and bats that nest or roost within the cave. Birds like the eastern phoebe use cave entries for nesting sites that are protected from the weather and wide temperature fluctuations. Several salamander species live in cave entries and forage both inside and out of the cave system.

Twilight Zone

The twilight zone is a very small niche within a cave ecosystem. It begins within a few feet of small openings, but it may start farther into the cave if the opening is large and admits a lot of light. Once in the twilight zone turns quickly block the light from reaching into the cave. The twilight zone is only that region that gets some natural light. Typically, the animals found in the entry are also found in the twilight zone. A few plant and algae species will gather enough light to survive in this area. In a few caves, parasitic plants can be found growing

Name _____

on the roots of surface trees that penetrate into the cave's twilight zone,

Dark Zone

The dark zone of a cave begins where there is no natural light. Residents in the dark zones depend on resources that brought into the cave from the outside world. Some resources are brought in on the wings of bats that leave the cave to forage and return to deposit guano on the cave floor. Streams that run along the surface before entering the cave also bring detritus and organisms from the outside. Some of the organisms that live in the dark zone are specially adapted to cave life and would not survive in the outside world. Terrestrial communities in the dark zone often depend on bats for food and communities with bat residents are more complex and larger than those without. Some complex cave ecosystems can support centipedes large enough to catch and eat bats. Aquatic systems with ties to the outside have juvenile salamanders, aquatic isopods, Planarians (flatworms), cave crayfish, amphipods and several species of fish.

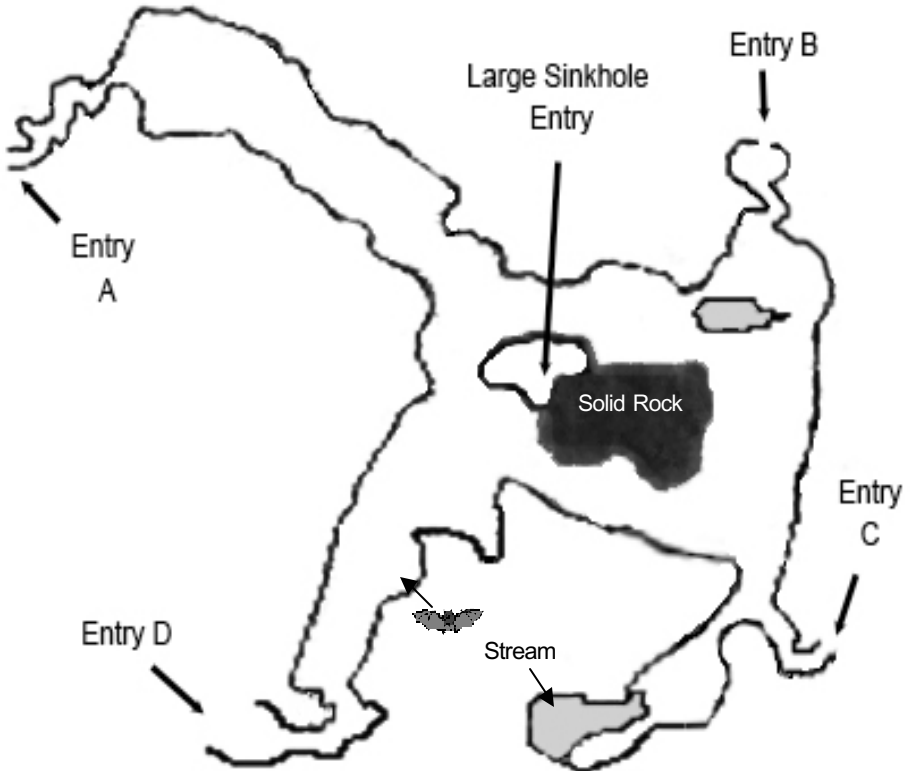
Creatures that spend their entire lives in the dark zone look different from their relatives on the surface. They are often blind and their skin may be pink, white or almost clear. Other sensory systems are better developed, such as longer antennae or better hearing. Their metabolisms are often very slow as an adaptation to living in nutrient poor environments.

Name _____

5 In The Caves Where We Live

Answer the following questions after reading about cave communities on pages 5-3 and 5-4.

1. On the diagram, mark the entry, twilight and dark zones for each of the five entries.



2. If a large colony of bats roosts in the cave during the summer. What affect would it have on the cave community? _____

_____

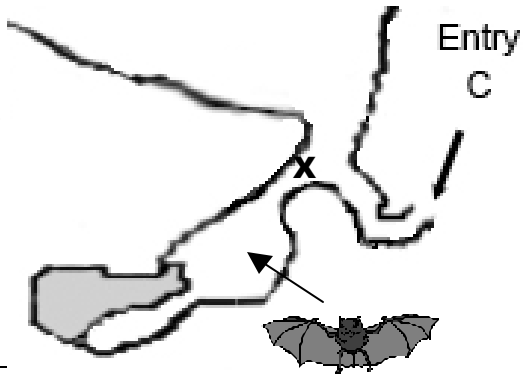
_____

3. The location of the colony is marked with a bat in the diagram above. What is one characteristic of an organism you'd expect to find there?

_____

Name _____

4. Another bat colony roosts in the area of the cave shown to the right. Passage "X" collapses while the bats are absent from the cave. What happens to the terrestrial cave community?



_____

_____

_____

_____

_____

_____

5. What happens to the aquatic community in the stream?

_____

_____

_____

_____

_____

6. In what zone or zones would you find:

   a. Dark Salamanders _____
   b. Walking Ferns _____
   c. Cave Crayfish _____
   d. Nesting Birds _____
   e. Pill Bugs _____

Caves Under Construction

The Science of Cave Formation

Materials

Soluble Stuff: several clear beakers or jars per group ● one funnel per group ● coffee filters ● spoons ● samples of several soluble materials such as sugar, salt, drink mix, instant coffee or tea, creamer, etc ● samples of several non-soluble materials such as sand, soil, coffee grounds, tea leaves, rice, etc. ● copies of Worksheet #1 ● very warm water

Vanishing Rocks: ● white vinegar ● samples of limestone ● samples of non-carbonate rocks ● copies of Worksheet #2 ● litmus paper ● several acidic substances such as citrus juice, grape juice, brewed tea, soft drinks, yogurt ● several items with base PH such as baking soda, detergent, and houseplant fertilizer ● clear jars, cups, spoons, and warm water for mixing and soaking ● raw eggs ● eyedroppers

Speleothem Garden: ● 4 jars (same size) per group ● 2 saucers or lids per group ● cotton yarn/string ● 4 paperclips per group ● Epsom salts ● baking soda ● magnifying glasses ● warm water ● red and green food coloring ● copies of Worksheet #3

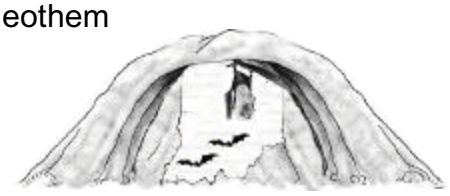
Constructing Karst: Bulk quantity of sugar cubes ● food coloring ● modeling clay ● toothpicks ● clear fish tanks (straight sides) or large square glass baking pans ● spray bottle(s) ● eyedroppers ● copies of Karst Diagram ● copies of Vocabulary Review

Teacher Background on Cave Formation

There are many different types of caves (volcanic, coral, wind, glacier) formed in many different ways, but this activity focuses on solution caves, also known as caverns. A cavern is a specific type of cave formed in soluble rock with the ability to grow speleothems. The caverns in Indiana are primarily solution caves, formed mainly in large areas of limestone bedrock in the central and southern parts of the state. These karst areas of Indiana also feature sinkholes, springs, and surface streams that suddenly disappear underground.

Water that contains an acid in solution can dissolve carbonate rocks such as limestone, dolomite, marble, chalk, gypsum, and salt. Rainwater picks up some carbon dioxide from the atmosphere, then absorbs much more from the decaying organic matter in the soil. Water and carbon dioxide form carbonic acid. The traditional theory of cave formation maintains that this weak carbonic solution is responsible for the formation of caves at the water table level. New studies, however, indicate that a stronger substance, sulfuric acid, may be important to cave formation as well. If the water table drops after a cave is formed, the cave will dry out and stop enlarging. It is at this point that cave formations called speleothems may begin to grow from minerals deposited by seeping and dripping water. Carbonic acid is the acid responsible for this process of speleothem development.

Caverns form under the surface of the ground in the



underlying bedrock and may not have an opening. Most entrances form after the cavern itself forms. Entrances can be caused by the collapse of a sinkhole, by erosion of a hillside, or they can be man-made.
The following experiments introduce students to the chemistry and geology associated with the formation of solution caves in limestone.

Soluble Stuff

This experiment introduces the concept that some materials will dissolve in liquid, and can later be removed through filtering or evaporation. Have students work in groups to complete the worksheet. Make sure each group gets at least one soluble material and at least one non-soluble material.

Extension Activity: Pour a very concentrated salt water solution in a shallow container and place in a windowsill or other warm place for a few days to observe evaporation.

Vanishing Rocks

This experiment demonstrates that acids can dissolve certain types of rocks. Wash the rocks ahead of time to remove loose dirt and let them dry. Students should work in small groups to complete Worksheet #2. They begin by observing that plain water has no effect on limestone. Next, students are introduced to acids and bases by testing the PH level of a variety of common substances. Students then soak a raw egg in vinegar (24-48 hours is best) to observe how an acidic substance dissolves the calcium in the shell. Finally, students soak one limestone rock and one non-carbonate rock with vinegar, which should cause the limestone to fizz, but have no noticeable effect on the other rock.

Extension Activity (teacher demonstration only!): Weigh and measure two rocks, one limestone and one non-carbonate. Place each in a beaker partially filled with a 20% solution of hydrochloric acid. Have students observe the difference in reactions between the rocks. Let the rocks sit in the solution for at least an hour (if the dissolving action stops on the limestone, add more acid.) Remove, clean and dry rocks, then weigh and measure again. The limestone rock should be noticeably smaller than it was before soaking, but the non-carbonate rock should be unchanged.

Speleothem Garden

Students will set up an experiment to mimic the way water deposits minerals to form cave "decorations," or speleothems. Review cave formation vocabulary words (speleothem, stalactite, stalagmite, column) from *Activity #2: Spelunker Speak* with students. Students should work in groups to mix two different solutions and observe the results over several days.

Worksheet answers: 1. The water evaporated 2. Answers will

vary. The Epsom salts will tend to form stalactites and stalagmites, while the baking soda will form more delicate cave "flowers." This illustrates how different minerals may form cave deposits that look quite different. 3. Minerals and
Organic matter 4. Have students refer back to Activity #2: Spelunker Speak. Seeping water: cave coral/popcorn, helicitites, and shields. Flowing water: Flowstone, which looks like a frozen waterfall.

Extension Activity: Using an eyedropper, drizzle cooking oil over some of the speleothems. Tell
students that the oil is like the oil on human hands when we touch actual cave formations. The oiled speleothems should stop growing.

Constructing Karst

This activity introduces students to some of the features of karst topography, and helps them understand how the action of water on soluble material can form such landscapes. Go over the karst terms and the diagram with students, then build a small sample karst landscape. Stack sugar cubes against the side of the clear glass aquarium or baking dish, then cover completely with clay. Poke a few holes with the toothpicks, then pour or squirt water onto the "landcape" to show students how the water will seep through the sugar and dissolve it. (Using food coloring makes this effect more vivid.) Let students work in groups to build their own larger and more complex karst landscape. Challenge students to try to "cause" as many karst formations as possible to form in their landscape. Finally, have students complete the Karst Vocabulary Review.

Worksheet answers: Water alone will not dissolve the rock; an acidic solution is needed to dissolve rock and form caves. Students may also mention that carbonic acid helps create cave formations.

Karst Vocabulary Review Answer Key

sin**k**hole	a depression in the surface of the ground caused by dissolving of the rocks beneath
lime**s**tone	a rock made up mainly of calcite from ocean animals
solu**t**ion	a type of mixture where the material cannot be filtered out
diss**o**lve	to disintegrate or break up
bedr**o**ck	the solid rock beneath the looser soils on the earth's surface
ca**r**bonic **a**cid	important for the formation of cave "decorations"
calci**t**e	many cave formations are made of this mineral
s**p**eleothems	a fancy word for cave formations
topograph**y**	the shape and physical features of the land
caver**n**	these form in soluble rock and can grow speleothems
eva**p**orate	to change into a vapor or a gas
sprin**g**	an issuing of water from the ground
sw**a**llow **h**ole	place where a stream disappears underground

Unscramble the letters in the boxes above to find a phrase that is important to Indiana bats.

karst topography

Name _____

Karst Vocabulary Review

Word Bank		
Bedrock	Evaporate	Spring
Calcite	Limestone	Swallow hole
Carbonic acid	Sinkhole	topography
Cavern	Solution	
Dissolve	Speleothem	

__ __ __ ☐ __ __ __ __ — a depression in the surface of the ground caused by dissolving of the rocks beneath

__ __ __ __ ☐ __ __ __ __ — a rock made up mainly of calcite from ocean animals

__ __ __ __ ☐ __ __ __ — a type of mixture where the material cannot be filtered out

__ __ __ __ ☐ __ __ __ — to disintegrate or break up

__ __ __ __ ☐ __ __ — the solid rock beneath the looser soils on the earth's surface

__ __ ☐ __ __ __ __ __ ☐ __ __ __ — important for the formation of cave "decorations"

__ __ __ __ __ ☐ __ — many cave formations are made of this mineral

__ ☐ __ __ __ __ __ __ __ __ — a fancy word for cave formations

__ __ __ __ __ __ __ __ __☐ — the shape and physical features of the land

__ __ __ __ ☐ __ — these form in soluble rock and can grow speleothems

__ __ __ ☐ __ __ __ __ __ — to change into a vapor or a gas

__ __ __ __ __☐ — an issuing of water from the ground

__ __☐ __ __ __ __ ☐ __ __ __ — place where a stream disappears underground

Unscramble the letters in the boxes above to find a phrase that is important to Indiana bats.

__ __ __ __ __ __ __ __ __ __ __ __ __ __ __

Name _____

Worksheet #1: Soluble Stuff

Word Bank		
mixture	solution	soluble
dissolve	evaporate	non-soluble

Directions

Make a mixture of *very warm* water and the following materials, one at a time. (A ***mixture*** is a combination of substances that is not combined chemically; you can separate out the parts again.) Describe each mixture. Does the material seem to disappear into the water? Is it evenly distributed throughout the water, or does some sink to the bottom or rise to the top? Then try to remove the material from the water by pouring it through a coffee filter placed in a funnel.

Material A **What is it?** _____

Describe what happens when mixed with water: _____

_____

_____

Will it filter out? _____

Material B **What is it?** _____

Describe what happens when mixed with water: _____

_____

_____

Will it filter out? _____

Material C **What is it?** _____

Describe what happens when mixed with water: _____

_____

_____

Will it filter out? _____

Name _____

Material D
What is it? _____

Describe what happens when mixed with water:

Will it filter out? _____

Dissolve means to disintegrate or break up. A ***solution*** is a special type of mixture where the substance dissolves, is evenly mixed throughout, and cannot be filtered out. The material seems to "disappear," although the water may change color.

Which mixtures were solutions? ___ A ___ B ___ C ___ D

If a material will dissolve in liquid, then we say it is ***soluble***. If a material will not dissolve and can be filtered out, then we say it is ***non-soluble.***

Which of your materials were soluble? ___ A ___ B ___ C ___ D

We could not filter these soluble materials out of the water, but there IS a way to separate the material from the water. Do you know what it is? Think about a mud puddle, which is a mixture of dirt and water. After a few sunny days, the puddle will dry up, right? The water will disappear, and all that is left is mud or dirt. So the water and the dirt are separate again, but how did it happen? Where did the water go? The water evaporated, or turned into a gas. To ***evaporate*** is to change into a vapor or a gas.

Say your group has a salt water solution, and you need to separate the salt and the water. How will you do it?

GROUP DISCUSSION
Get ready for our next experiment by discussing this question with your group:

Do you think rocks are soluble?

Name _____

Worksheet #2: Vanishing Rocks

Word Bank			
acid	base	calcite	limestone
carbonate rock		non-carbonate rock	

Caves in Indiana are formed in a rock called ***limestone.*** Limestone is made up mostly of the mineral ***calcite.*** This calcite usually comes from the shells of ocean animals. This means that the limestone was deposited when a warm ocean covered Indiana!

1. With eyedroppers, coat your limestone rock with plain water. What happens?

   _____

As you can see, water alone is not very good at dissolving rocks; however, when water contains an ***acid*** in solution, it can dissolve *certain types* of rocks over long periods of time.

An ***acid*** is a water-soluble, sour-tasting chemical compound. In chemistry, materials can be grouped by their properties, or characteristics. One property is PH, which tells you whether a substance is an acid, a base, or a neutral. (A ***base*** is just the opposite of an acid, and a neutral is neither an acid or a base.) Scientists use litmus paper to test the PH of substances; an acid will turn the paper red, and a base will turn it blue.

2. With the litmus paper, test the following common household materials to see if they are acids or bases. If the material is a powder, dissolve it in warm water and then test the solution.

Material A **What is it?** _____

_____ **Acid or** _____ **Base?**

Material B **What is it?** _____

_____ **Acid or** _____ **Base?**

Material C **What is it?** _____

_____ **Acid or** _____ **Base?**

Material D **What is it?** _____

_____ **Acid or** _____ **Base?**

Name _____

3. Test the PH of vinegar. Is it an acid or base? _____

4. To test the dissolving action of acids, gently place a raw egg in a container of vinegar. Make sure the egg is completely covered in vinegar. Check the egg in a day or two. How has it changed?

The egg shell contains calcium. You have probably heard of calcium; it is also found in milk, and in bones and seashells. The acidic vinegar reacted with the calcium in the egg shell, causing it to dissolve.

Some rocks contain something called calcium carbonate. These rocks are called ***carbonate rocks*** and include limestone, chalk, and marble.

5. Have some members of your group use the eyedroppers to coat your limestone rock with vinegar. Have other group members coat your other rock (the ***non-carbonate rock***) with vinegar. Compare the reactions.

What happened? **Limestone** _____

Non-carbonate rock _____

6. So, are rocks soluble? Yes, sometimes. To dissolve rocks, you need two things: a sour-tasting chemical compound called an _____ and a certain type of rock called a _____ rock.

Name _____

Worksheet #3: Speleothem Garden

New Words
carbonic acid
saturated
organic matter

To make caves, we need two important ingredients: carbonate rocks, which are soluble, and an acid. The main acid responsible for the formation of cave decorations is called ***carbonic acid***. Carbonic acid reacts with limestone to deposit calcite formations called speleothems in caves.

Most are speleothems are white. They can be pale green or red if they contain minerals or organic matter carried from the surface by water.

Organic matter is matter that contains living things (plants and animals) or non-living materials that come from plants and animals such as manure, seeds, or bones.

Follow these directions to see how cave formations are created.

a. Dissolve Epsom salts in very warm water until the water is ***saturated.*** A solution is saturated when as much solid material as possible dissolves in the liquid and any additional material sits on the bottom.
b. Add a few drops of green food coloring and fill two of your jars about half full with the solution. Place them next to each other with a lid or saucer in between them.
c. Cut about one foot (12 inches) of cotton string and tie a paperclip onto each end. Soak the string in the solution in one of your jars so it is completely wet. Hang the string between the jars, with the paperclips well down inside each jar. Make sure the string is hanging over the saucer in a loop that is lower than the water level in the jars.
d. Dissolve baking soda in very warm water until the water is saturated. Add a few drops of red food coloring. Fill two more jars and set them up with the saucer and the string just like you did for the first set of jars.
e. Observe the jars over several days. Do not touch the delicate formations! They are very fragile.

What happened?
The water carried the Epsom salts and baking soda along the string. The solution dripped off the loop onto the saucer. You should have stalagmites and stalactites and other "formations" on your saucer.

1. What happened to the water that carried the soda and salt along the loop? Why isn't your saucer full of water?

Review Words

calcite	evaporate	speleothem
stalagmite	column	stalactite

Name _____

2. On the back of this sheet, draw the formations made by the Epsom salts and by the baking soda.
How are the formations alike?

How are they different?

3. If these were real cave formations, what would make them red and green?

_____ and

_____ _____

Stalactites and stalagmites form in caves this way when water that contains dissolved calcium drips from the cave ceiling. Eventually, stalactites and stalagmites may connect to form a column. Seeping water and flowing water create formations that look different than those formed by dripping water.

4. Draw and name one cave formation made by seeping water and one made by flowing water.

Name _____

Worksheet #4: Constructing Karst

Most rainwater is a very weak acid solution. Why is this important for cave formation?

_____

_____

_____

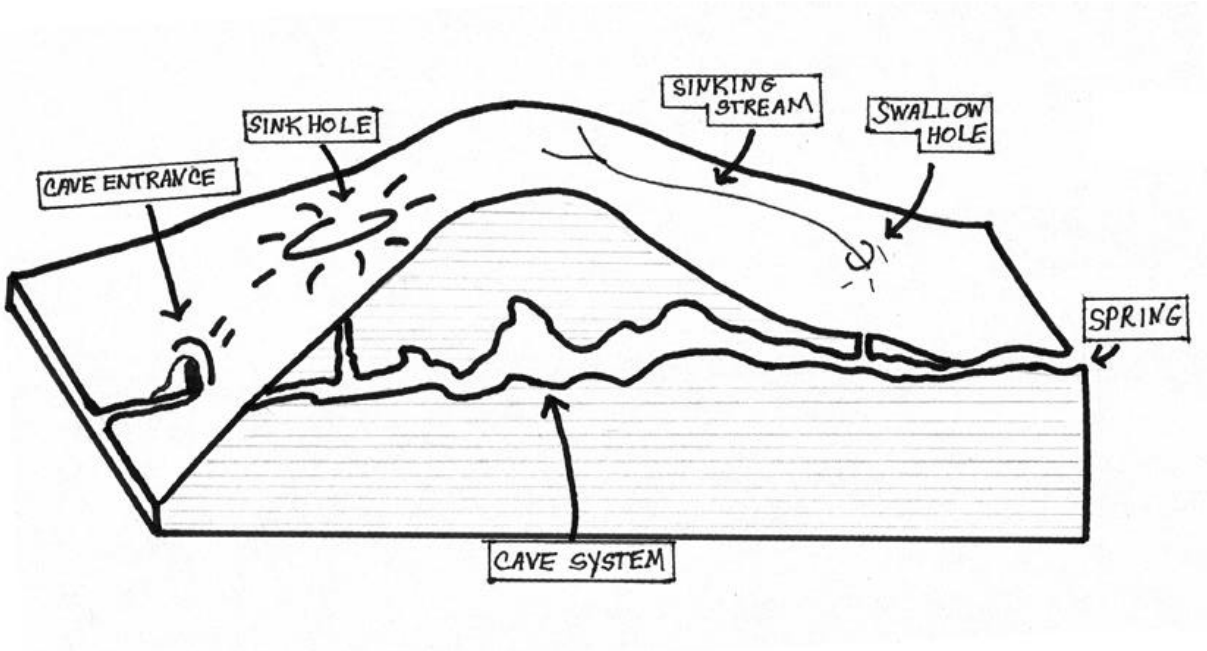
Indiana contains a large amount of karst topography. Study the karst diagram, then follow your teacher's instructions to build a karst landscape.

Important Words

Topography: the shape and physical features of the land.

Bedrock: the solid rock beneath the looser soils of the earth's surface

Karst: a landscape featuring caves, sinkholes, and underground streams formed when acidic water dissolves soluble bedrock such as limestone



Karst Features

Spring: an issuing of water from the ground

Sinkhole: a depression in the surface of the ground caused by the bedrock dissolving

Cavern: a type of cave formed naturally in soluble rock with the ability to grow speleothems

Swallow hole: the place where a surface stream disappears underground

7 Caves & Humans—So Happy Together?

Impact of Human Use

Materials: Computer(s) to access weather statistics ● Background Information ● Worksheets I & II

Read background information with students and discuss. You may want to have students work in groups to complete Worksheet I: Temperature and Air Movement in Caves and Worksheet II: How Does Human Activity Affect Indiana Caves and Indiana Bats? For Worksheet II, you may want to have a different group work on each cave, then have groups report back to the class.

Answer Key

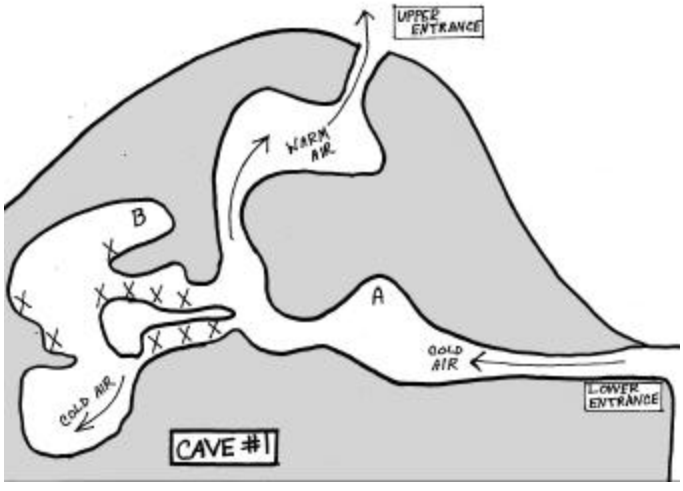
Worksheet I: Temperature and Air Movement in Caves

Ground temperature in southern Indiana: 56 degrees Fahrenheit, 13 degrees Celsius

NO, this temperature is too warm for Indiana bat hibernation.

Worksheet II: Does Human Activity Affect Indiana Caves and Indiana Bats?

Cave #1: Native American Chert Mining

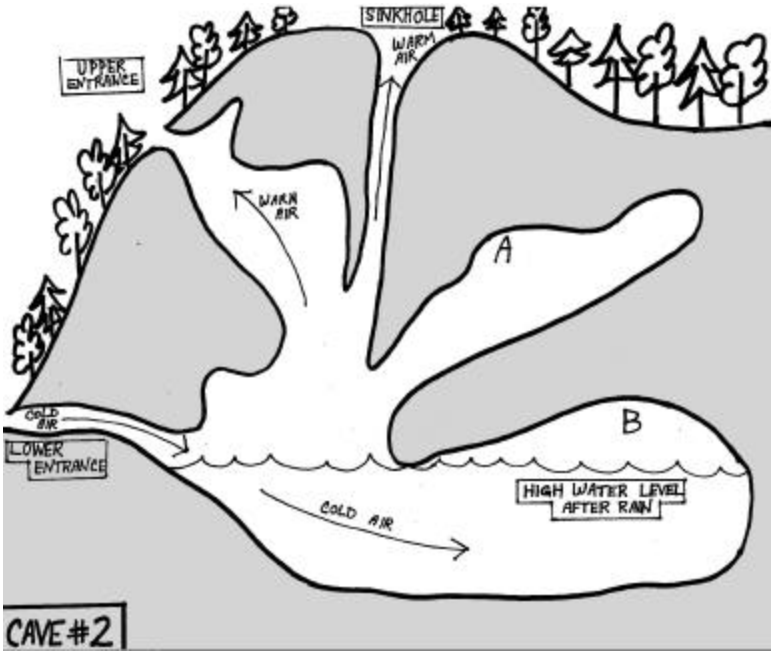


2. Yes, the heat from the pine torches could heat up the area around hibernation location B.

3. Yes, the heat from the pine torches could increase the air flow within the cave. Increased heat rising out of the cave at the sinkhole could create a vacuum, drawing in more cold air from the entrance. Some cave locations might be warmer, while others might be colder.

4. Location A bats should not be affected much, since they will not be disturbed by humans. They might benefit some if colder air is drawn into the cave. The mining would be bad for the bats at location B. The pine torches might create too much heat for the bats to remain in hibernation, and humans in the same "room" with them would disturb their hibernation.

Cave #2: Changes in Land Use



2. Closing off the sinkhole and blocking the upper entrance causes less air flow in the cave, because the exits for warm air are blocked.

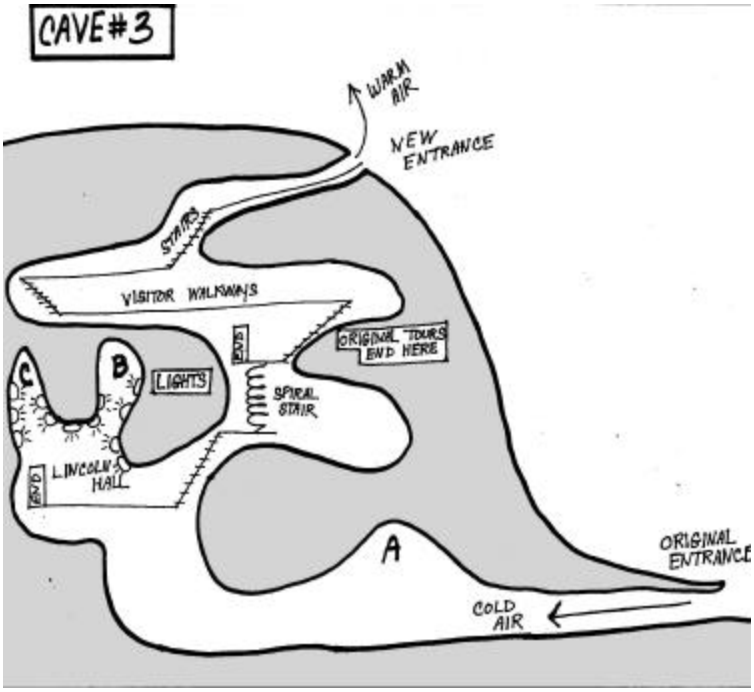
3. Yes, all locations could become warmer (closer to ground temperature) due to decreased air movement. Location B would be the least affected, since cold air coming in the lower entrance would sink into that "room."

However, from there, the cave passage slopes upward, so the cold air coming in the lower entrance would not move far into the cave. Warm air would be trapped in the upper levels of the cave.

4. Cutting down the trees causes the cave to flood after heavy rain, which could drown the bats or trap them in the spring when they awaken (such as at location B). Cutting down the trees will also cause greater fluctuations in the humidity level of the cave; between rains, the cave may become too dry for the bats, who need at least a 74% humidity level.

5. Yes, we think male Indiana bats spend the summer near the hibernaculum, and they need roosting trees. Also, both male and female bats need trees to roost in during "swarming" in the autumn.

Cave #3: Developing Caves for Tours



2. Better air flow was created by adding a second entrance. Some parts of the cave became colder, some warmer. More cold air will now be drawn into the lower parts of the cave.

3. The Indiana bats benefited. Increased air flow created more pockets of colder air for them to hibernate (locations B & C).

4. Humans disturbing them and too much heat created by the lights.

5. Answers will vary. The best solution may be to close the entire cave during hibernation months; an alternative more acceptable to the cave developers might be to close the part of the cave where the bats hibernate in the winter, and disconnect the lights in that section during hibernation. Tours could be offered throughout the cave in the summer, but only in the original tour section in the winter, when the bats are hibernating.

Name _____

Background Information: Caves & People—So Happy Together?

BACKGROUND INFORMATION

Hibernation Needs of the Indiana Bat

Hibernation is something many bats do in order to survive when their food sources are scarce. Indiana bats rapidly build up body fat in the late summer and early autumn; these fat reserves have to last until spring. The bats need to wake up from hibernation as little as possible; too much awakening will cause them to burn too much body fat and they will die before spring. Bats can wake up during hibernation because of temperatures that are too warm, or if they are disturbed by humans. They also might wake up to move to a better hibernation spot within the same cave. Before entering the hibernation cave in the autumn, male and female Indiana bats "swarm" around cave entrances to mate at dusk and dawn, and roost in nearby trees during the day.

> The Indiana bat requires stable hibernation temperatures **between 4 and 8 degrees Celsius**, and a high relative **humidity above 74%.**

The summer habits of the Indiana bat are not well known. Females may migrate up to 480 km (almost 300 miles) from the hibernaculum to reach their summer nursery roosts. Some males migrate, but most remain in the general area of the hibernaculum during the summer, roosting in nearby trees.

Human Uses for Indiana Caves

Caves in Indiana have been used throughout history for the following:

- Mining chert and aragonite to make prehistoric artifacts such as arrowheads
- Mining saltpeter to make gunpowder
- Use of springs for drinking water and to power mills
- Refrigeration of perishable foods
- Cemeteries
- Scientific studies by geologists, archaeologists, and biologists
- Recreational use/development for tourism

Discussion: Which of the above do you think might affect hibernating bats?

Name _____

Worksheet I: Temperature and Air Movement in Caves

Worksheet I: Temperature and Air Movement in Caves

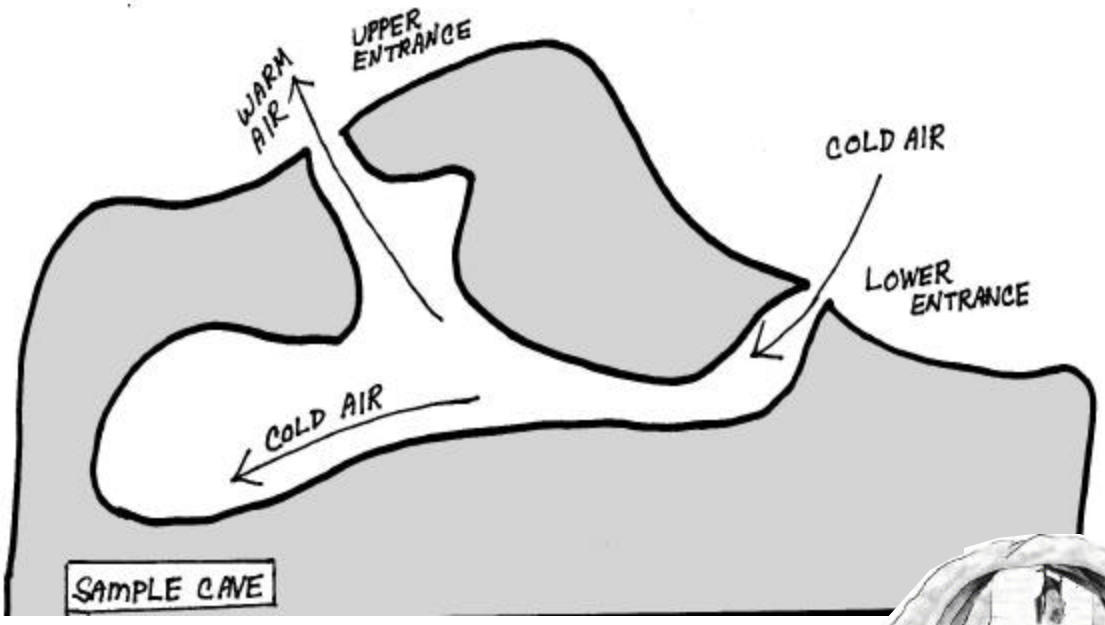
Caves get their temperatures from the ground around them. To calculate the ground temperature several feet below the surface, take the average low temperature and the average high temperature in southern Indiana, and average those. Or, go to http://www.weatherbase.com/ and select a southern Indiana location such as Evansville to see the average annual temperature.

Ground temperature in southern Indiana: _____

Is this the right temperature for Indiana bat hibernation? _____

So… how do bats hibernate successfully in southern Indiana?

Many cave systems have “chimney effect” air flow. Because warm air rises and cold air sinks, cave passages that slope downward will trap cool air, while cave passages that slope upward will trap warm air. Caves with two or more openings have better air flow than caves with a single entrance; cool air will sink into the cave and warm air will be pushed out the higher opening. When warm air rises, it may create a vacuum, which will then draw in additional cool air.

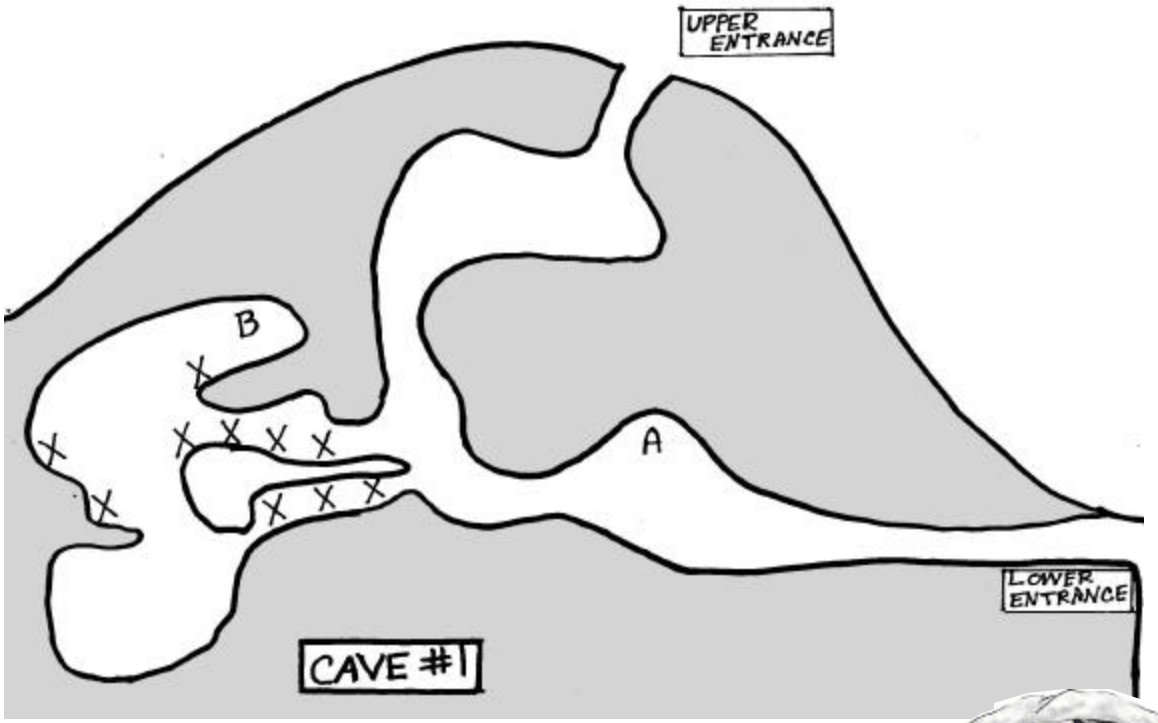


Name _____

7 Worksheet II: How Does Human Activity Affect Indiana Caves and Indiana Bats?

Cave #1: Native American Chert Mining

Native Americans carried out mining operations in Wyandotte Cave for thousands of years before Columbus arrived in the New World. Mining was particularly intense from 1500 BC to 600 AD; during this time, the native Americans chipped out a blue-gray material called Wyandotte chert. They traded the chert to other native groups up to 1000 miles away! Wyandotte chert was used to make practical items such as arrowheads, and also used to make religious objects. Archaeologists have found the remains of many pine torches in the cave, which the miners used for light as they worked. In Cave #1, Indiana bats hibernated at sites A and B. Chert mining operations are marked with an X. Suppose that native Americans mined chert for 10 hours a day, every day during the winter months (November-March). Miners entered the cave through the upper entrance, using ropes and ladders to reach the mining area; they did not know about the lower entrance to the cave.



Name _____

1. Draw the winter air flow through the cave, using red arrows for warm air and blue arrows for cold air.

2. Could the mining affect the temperature within different parts of the cave?

_____

_____

_____

_____

_____

3. Could the mining operations affect the air flow within the cave?

_____

_____

_____

_____

_____

4. How do you think the hibernating bats at location A will be affected by the mining?

_____

_____

_____

What about the bats at location B?

_____

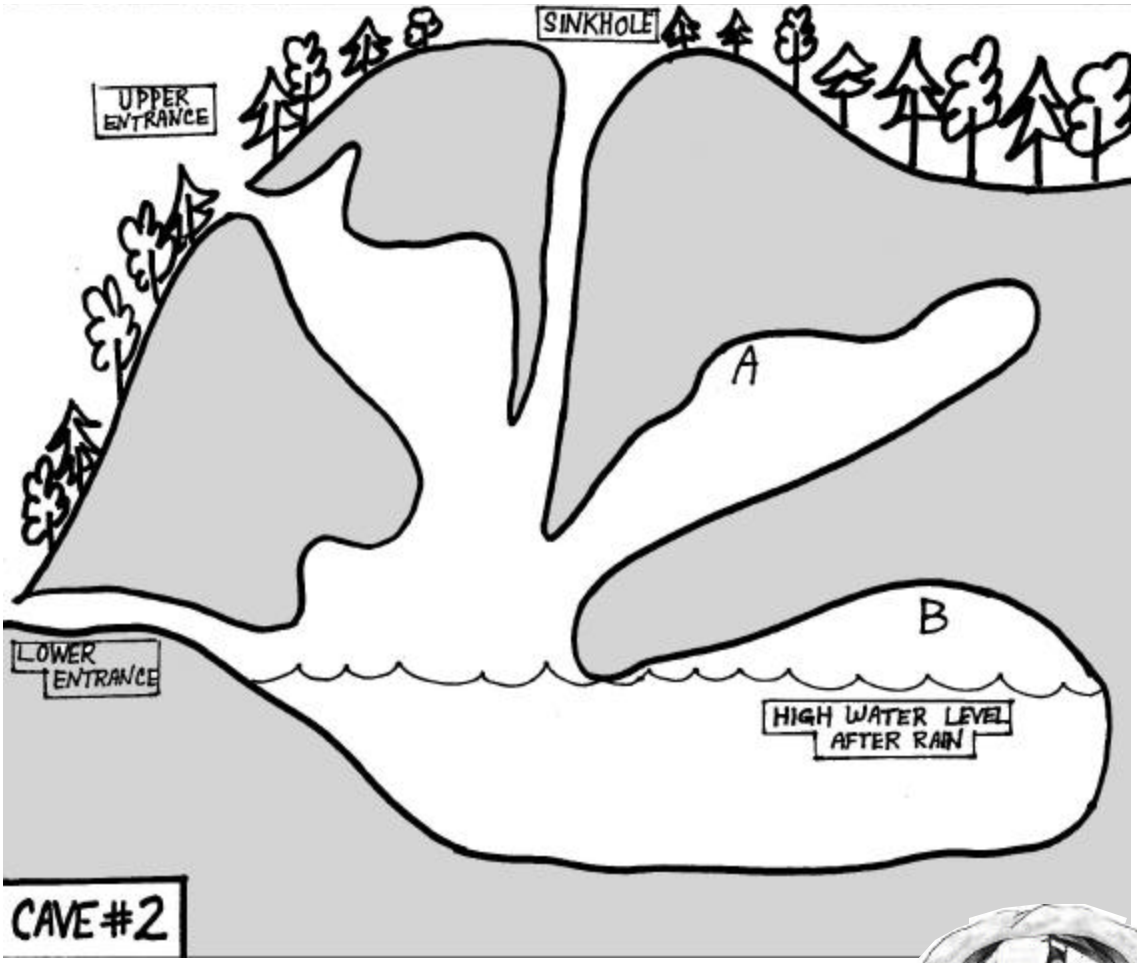
_____

Name _____

Cave #2: Changes in Land Use

Many caves in southern Indiana are threatened by what happens on the surface. Deforestation (cutting down all trees in a large area) can change air flow, temperature and humidity in a cave. Forests capture rain and release it slowly underground. Without the forest, heavy rain can drain away very rapidly, causing the cave to flood. During times of little rain, though, cutting the forests can make a cave drier (less humid). So a forest cover above a cave may help keep the temperature and humidity more stable within the cave.

Cave #2 was originally a dry cave with an upper entrance, a lower entrance, and a large sinkhole. The cave is on private property, and the landowner decided not to open the cave to the public, because she knew that large numbers of Indiana bats hibernated there. In fact, she posted "No Trespassing" signs around the cave, sealed the upper entrance with a gate. She also cut down the entire forest above the cave and used the cut trees to fill the sinkhole. Now, lower portions of the cave flood regularly after heavy rain.



Name _____

1. Draw winter air flow through the cave BEFORE the sinkhole was blocked, using red arrows for warm air and blue arrows for cold air.

2. Explain how closing off the sinkhole affects air movement within the cave.

_____

_____

_____

3. Explain how closing off the sinkhole and blocking the upper entrance could affect temperature at the three hibernation locations.

_____

_____

_____

_____

4. List two ways that cutting down the trees above this cave might be bad for the ***hibernating*** bats.

_____

_____

5. Would cutting down the trees make any difference to the bats during the summer or early autumn, before they go into hibernation? If so, explain.

_____

_____

_____

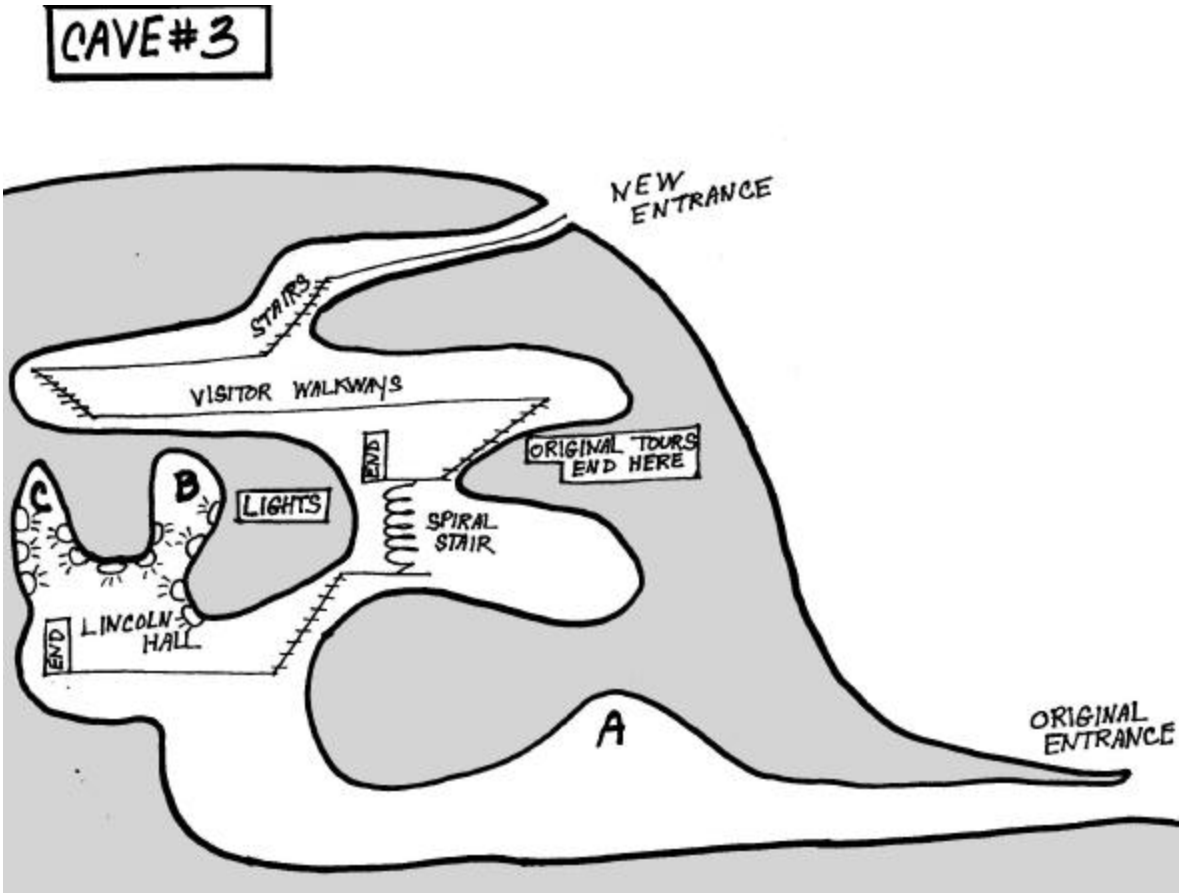
_____

Name _____

Cave #3: Developing Caves for Tours

There are five commercial caves in southern Indiana. Frequently, when caves are developed for tours, new entrances are blasted and bright lights are installed. Some caves have quite a large number of visitors; for example, over 75,000 people tour Marengo Cave every year!

Cave #3 originally had only one entrance, and Indiana bats hibernated only at location A. When the cave was developed for tours, a second entrance was blasted and walkways built so visitors could tour the upper level of the cave. For several years, the number of Indiana bats hibernating in the cave increased. In fact, the bats added two new hibernation locations at B and C. Then, high-powered fluorescent lights were installed in Lincoln Hall so the beautiful dripstone formations in this "room" could be included on the tour. Suddenly, large numbers of Indiana bats started dying during hibernation. Tours go on all year.



Name _____

1. Draw (winter) air flow through the cave using red arrows for cold air and blue arrows for warm air, now that it has two entrances.

2. How did winter air flow within the cave change when the second entrance was blasted?

_____

_____

_____

3. Did the new entrance harm or benefit the Indiana bats?

_____

_____

_____

4. What are ***two*** possible reasons that the bats started dying over the winter once the lights were installed in Lincoln Hall and it was added to the tour?

_____

_____

_____

5. Can we save the Indiana bats and still allow visitors to see this beautiful cave? Write a paragraph explaining your solution to this problem.

8 Cave Conservation—Why Care?

Research and Role Play

Materials: Article (pg. 8-3) ● Research worksheet (pg. 8-4) ● Research materials: books, magazines, encyclopedias, internet, etc.

As a group, read the article on page 8-3 and answer the discussion questions.

Answers:

1. A cave that may house bats has been discovered. What should happen to the land the cave is on?
2. The farmer/landowner, the devoloper, and bat biologists.
3. Possible answers: conservationists, spelunkers, neighbors, the government.
4. Possible answers: nothing, the developer could bulldoze it and build a mall there, it could become a research site, it could be opened up to explorers and tourists.

After discussing the article, assign students, either alone or in groups, to each group of people who are interested in the cave (landowner, developer, spelunkers, etc.) and have them research that particular group and its interest in the cave. The groups/students should then present their information to the rest of the class by role-playing the court hearing mentioned in the article:

1. The teacher is the judge and the class will act as a jury.
2. The groups take turns presenting their case to the judge. They should articulate what they believe should happen to the land and why it is the best solution.
3. The "judge" should then lead a discussion with the "jury" as they decide the fate of the land. Who presented the strongest case? What are the pros and cons of each scenario? Is there a compromise?

Name _____

8 Cave Conservation—Why Care?

After reading the following article that recently appeared in The Daily Clarion newspaper, answer the questions about the different groups that have an interest in the sale of this land.

The Daily C

Saturday, September 8, 2007

Cave Discovery Fuels Contr

EVANSVILLE – Paul Glen, owner of forty acres at 123 N. County Rd., came under fire yesterday for wanting to sell to local developer, Ima Builder, owner of Buildamall, Inc. who told reporters that the deal has been delayed because of sightings of federally endangered Indiana bats and the discovery of a small cave on the land.

Surveyor Michael Earth, a member of Bat Conservation International, found the cave and sighted the bats. Earth called the U.S. Fish and Wildlife Service and the Vanderburgh Co. Conservation Office. A hearing has been scheduled for next week to decide what should happen to the land.

Glen, who is selling off most of his land so he can retire from farming, claims that "since the boys have grown and moved away, I haven't gone out hunting. I didn't even know there was a cave there, and I never saw any bats."

Luna Wing, a bat biologist at Big University, says she's not surprised. "Indiana bats are very small. They fly at night and the traffic in and out of the cave would have happened mostly in the spring and fall when Mr. Glen was planting and harvesting." She goes on to say that the bats are most likely using the cave as a hibernaculum, a place

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1. What is the controversy in the article?

2. Who are the people involved in the "controversy"?

3. Who else might be interested in the outcome of the case?

4. What are some of the possible things that could be done with the cave?

Name _____

8 Cave Conservation—Why Care?

Research and Role Play

What group are you a part of?
How does your group use caves?
What does your group want to happen to the cave?
List the resources you used:

Bravo, Bats!

Why Bats Deserve Our Thanks

Materials: Beneficial Bat Fact Sheets ● Giving Thanks for Bats Recipe Worksheet ● Common food items/spices that are dependent on bats such as chocolate, orange juice, ketchup, French fries, peanut butter, apple, banana, black pepper, coffee beans, jelly/jam, corn, oatmeal, hamburger buns with sesame seeds, allspice, basil, cloves, ginger, whole coconut ● bananas, strawberries, and dipping chocolate and/or ● assorted fruit, flaked coconut, and pecans for fruit salad

Teacher Instructions

Hand out copies of Beneficial Bats Fact Sheet, and use it to discuss ways many food items and agricultural products are dependent on bats for insect control, seed dispersal, pollination, fertilizer, and ecosystem maintenance. Help students define words in word bank. Display common food items (see above) that students are familiar with; let students investigate, smell, taste, etc. items they might not be familiar with such as whole bean coffee, spices, figs, and peppercorns.

Bring in or make in class: fruit salad with coconut and nuts and/or chocolate-dipped bananas and strawberries as samples of snacks that we can enjoy thanks to bats.

Have students complete the Giving Thanks for Bats Recipe Worksheet.

Answer key: flour (wheat), margarine (see coconut), white and brown sugar (see dates and coconut), ginger, cloves, and pumpkin should be highlighted.

Extension Ideas:

For homework, each student should find a recipe at home, write it on the blank recipe cards on page 9-6, and highlight the bat-dependant ingredients.

Create a recipe book of bat-dependent dishes. Have each student bring from home or find on the internet one or more recipes that contain at least two bat-dependent ingredients. Have students organize the recipes into a book illustrated with bats and interspersed with interesting bat facts (such as how many insects bats can eat in an hour, etc)

Beneficial Bats

Word Bank

pollinate	disperse	beneficial	insectivore	carnivore
pollen	nectar	fertilizer	ecosystem	dependent

Did you know that without bats, we might not be able to enjoy some of our favorite foods such as peanut butter, chocolate, bananas, bread, French fries, ketchup or orange juice? There are over 1,100 species of bats, and they live on every continent except Antarctica. Only 3 species of bats suck blood. Most (70%) eat insects. The other 30% of bats eat fruit, pollen, or nectar, or are carnivores. Most of what we eat comes from plants. Bats help provide us with these foods, and many other products, by eating insects that destroy certain plants, by pollinating plants and dispersing seeds, and even by providing fertilizer.

Bats also help keep humans healthy. We obtain 80 different medicines from plants that rely on bats for their survival. Bats keep us from getting sick by eating disease-carrying insects, such as mosquitoes which carry malaria and West Nile virus. Bats also protect the environment; if bats were not around to eat so many insects, we would have to use many more harmful pesticides, which can harm animals, including us!

Bats eat insects that would damage or destroy a wide variety of agricultural products. Small bats can easily eat up to 2,000 insects every night. Here are just a few foods that bats save from insects.

- Vegetables: asparagus, bees, beans, carrots, celery, corn, cucumbers, eggplant, spinach, lettuce, broccoli, cauliflower, cabbage, olives, peas, potatoes, tomatoes and peppers.
- Fruit: apples, avocadoes, cherries, citrus fruit, grapes, peaches, pears, pumpkin, squash, and all sorts of berries such as blackberries, blueberries, strawberries and cranberries.
- Seasonings: garlic, basil, ginger, honey (Bats eat insects whose larvae destroy beehives.)
- Seeds & Grains: oats, rice, wheat, and sesame seeds.
- Nuts: almonds, pecans, peanuts, and pistachios.
- Other: coffee and mushrooms.

We usually think of bees and butterflies as pollinators of flowers, but **bats are major pollinators** as well. The following items depend on bats for pollination.

- Bananas
- Dates (Date palm trees are also tapped for the sweet sap, which is turned into sugar and molasses.)
- Coconut (The coconut palm tree also give us coconut palm oil, which is used to make many products such as candy bars, soup, sugar, soap, ink, margarine and cosmetics.)
- Cloves (In addition to being used as a spice, cloves are used in perfumes and medicines.)
- Vanilla
- Brazil nuts
- Avocadoes

Bats help spread seeds of many plants over a wide area, making sure that more plants grow and produce food. Bats may carry off a piece of fruit, eat the fruit and drop the seeds some distance from the original plant, or they might eat the seeds, which then pass through their bodies and are discarded in their feces. Without bats to spread seeds, we might not have these tasty treats.

- Almonds and cashews
- Figs
- Allspice
- Chocolate (Chocolate is made from the cacao tree. Fruit bats eat the cacao fruit pulp and discard the cocoa bean, which will grow into a new tree. This is especially important because cacao fruit won't fall from the tree by itself, so we depend on bats to provide us with more cacao trees.)

Bat guano, or feces, **makes a very rich fertilizer**. One particular seasoning is very dependent on bat guano: peppercorns, from which we make black pepper.

The rainforests of the world depend on bats to spread seeds, pollinate plants, and control insects. Bats are responsible for 90% of rainforest reforestation. We rely on many rainforest products every day such as rubber, medicines, coffee, chocolate, and bananas. About 80% of what we eat and one quarter of our medicines come from the rainforest.

Name _____

Giving Thanks for Bats
Recipe Worksheet

Instructions

What would Thanksgiving be like without pumpkin pie? Without the help of bats, we might not have this popular Thanksgiving dessert. Here is a basic recipe for pumpkin pie. Highlight the ingredients that are dependent on bats in some way (you may use your Fact Sheet).

Pumpkin Pie

Ingredients

Crust:

- 1 cup flour
- Dash salt
- 1/2 cup (1 stick) margarine
- 2 1/2 Tablespoons cold water

Filling:

- 3 eggs
- 1 egg yolk
- 1/2 cup white sugar
- 1/2 cup packed brown sugar
- 1 teaspoon salt
- 1/2 teaspoon cinnamon
- 1/2 teaspoon nutmeg
- 1/2 teaspoon ginger
- 1/4 teaspoon ground cloves
- 1 1/2 cups milk
- 1/2 cup heavy whipping cream
- 2 cups pumpkin (canned or fresh)

Directions

Preheat oven to 425 degrees. For crust, mix flour and salt in a bowl; cut in margarine with a fork until crumbly. Add water and mix until a ball is formed. Roll out on a floured surface into a circle slightly larger than your pie pan. Place the crust in the pan; fold and crimp the edges. For the filling, in a large bowl, combine eggs, egg yolk, white sugar and brown sugar. Add salt, cinnamon, nutmeg, ginger and cloves. Gradually stir in milk and cream. Stir in pumpkin. Pour filling into pie crust. Bake for 10 minutes. Reduce heat to 350 degrees and bake for an additional 40 to 45 minutes, or until filling is set.

Name _____

Bravo Bats! Recipe

Recipe Title:

Ingredients:

Directions:

10 Pest Control — It All Adds Up

Word problems

Materials: worksheet pages 10-3—10-5 ● pencils ● calculators (if desired)ial 10)

Answer Key

1. 1/7 x 4/5 = **4/35 kg**
2. 150 x 4/35 = 120/9 = **13 1/3 kg**
3. alfalfa weevil – 320,000 x 1/20 = **16,000 acres** ; potato leafhopper – 320,000 x 1/5 = **64,000 acres**
4. 1 ÷ .005 = **200 weevils**
5. 200 x 150 = **30,000 weevils**
6. 450,000 x 1/2 = **225,000 bats**
7. 4/5 - 1/2 = **3/10 is non-beetle pests**
8. $30 x 3000 = **$90,000**
9. 5 million x 2/5 = 2 million acres x $20 = **$40,000,000**
10. **Nocturnal moths** are the insects selected most often by Indiana bats.
11. Order of the Indiana bat's preference:
    1) **Nocturnal moths**
    2) **Small beetles**
    3) **Flies**
    4) **Leafhoppers and other Homopterans**
12. 4034 ÷ 11.2 = **360 bats**

**The authors would like to thank Larry Bledsoe, Purdue Agronomy Specialist for service above and beyond the call of duty, including determining the weight of an alfalfa weevil. The authors would also like to thank Larry Caplan, extension educator-horticulture with the Purdue University Cooperative Extension Service, for directing our questions to such a great source. Information regarding the foraging habits and ecology of the Indiana bat and the big brown bat were gleaned from a variety of sources. Dr. John Whitaker's work on the foraging ecology of bats was instrumental. Special thanks are also due to Andrew King of the United States Fish and Wildlife Service for supplying updated figures for the US population of Indiana bats. Any mistakes or oversimplifications are ours.

Name _____

10 Pest Control & Hibernation— It All Adds Up

Solve the following problems about bats' eating habits and hibernation. Show your work.

	Work Area
1. If 1/7 of a single Indiana bat's diet is from the order Homoptera, how many kilograms of Homopterans would an Indiana bat eat in year if it ate 4/5kg of insects? _____ kilograms	
2. How many kilograms of Homopterans would a colony of 150 Indiana bats eat in a year? _____ kilograms	
3. Homopterans include the alfalfa pests like the potato leafhopper and the alfalfa weevil. There are about 320,000 acres of alfalfa in Indiana. Approximately 1/20 is treated for the alfalfa weevil and 1/5 is treated for the potato leafhopper. How many acres in Indiana are treated for each alfalfa pest? alfalfa weevil: potato leafhopper: _____ acres _____ acres	
4. An alfalfa weevil weighs approximately 0.005 g. If a female Indiana bat eats a gram of alfalfa weevils in one evening, how many weevils did she eat? _____ weevils	
5. How many weevils does her colony of 150 individuals eat? _____ weevils	

Name _____

6. Half of all the Indiana bats hibernate in Indiana. Currently the population is estimated at 450,000 bats nationwide. How many bats hibernate in caves in Indiana? _____ bats	
7. Agricultural pests make up 4/5 of the big brown bat's diet. About ½ of the big brown bat's diet is made up of leaf beetles, June beetles, Japanese beetles, and other beetle pests). What proportion of the big brown bat's diet is made up of pest insects that are not beetles? _____ non-beetle pests	
8. A colony of 150 big brown bats eat enough cucumber beetles each summer to prevent 33 million rootworm larvae from being born. Roughly 3,000 acres of cucumbers, squash, melons, and pumpkins in the state of Indiana are treated to control cucumber beetles at a cost of $30 per acre on average. How much would farmers in the state of Indiana save if big brown bat colonies protected their crops? _____ savings	
9. Indiana farmers treat approximately 2/5 of the corn grown in the state for rootworms at a cost of approximately $20 per acre. Indiana farmers typically plant about 5 million acres of corn. How much would they save if big brown bat colonies protected their crops? _____ savings	

Name _____

10. Bats are one of the few predators of night flying insects. The larvae of nocturnal moths like cutworm, tobacco hornworm, and tomato hornworm are crop pests and make up between 28.5 % and 34 % of the Indiana bat's diet. Flies and their relatives make up between 15 % and 28% of their diet. The diet of Indiana bats consists of between 4.5% and 15 % leafhoppers and other Homopterans. Small beetles like the alfalfa weevil and the Asiatic oak weevil make up between 16 % and 32% of the Indiana bat's diet. Which insect group is selected the most often in the diet of the Indiana bat?

_____

11. Rank the insects described above in the order of the bat's preference from most to least eaten.

1) _____

2) _____

3) _____

4) _____

12. Indiana farmers planted 4034 acres of tobacco in 2002. If an Indiana bat forages over approximately 11.2 acres per bat in midsummer when thehornworm emerge as adults, how many bats would be needed to help control hornworm in Indiana's tobacco fields.

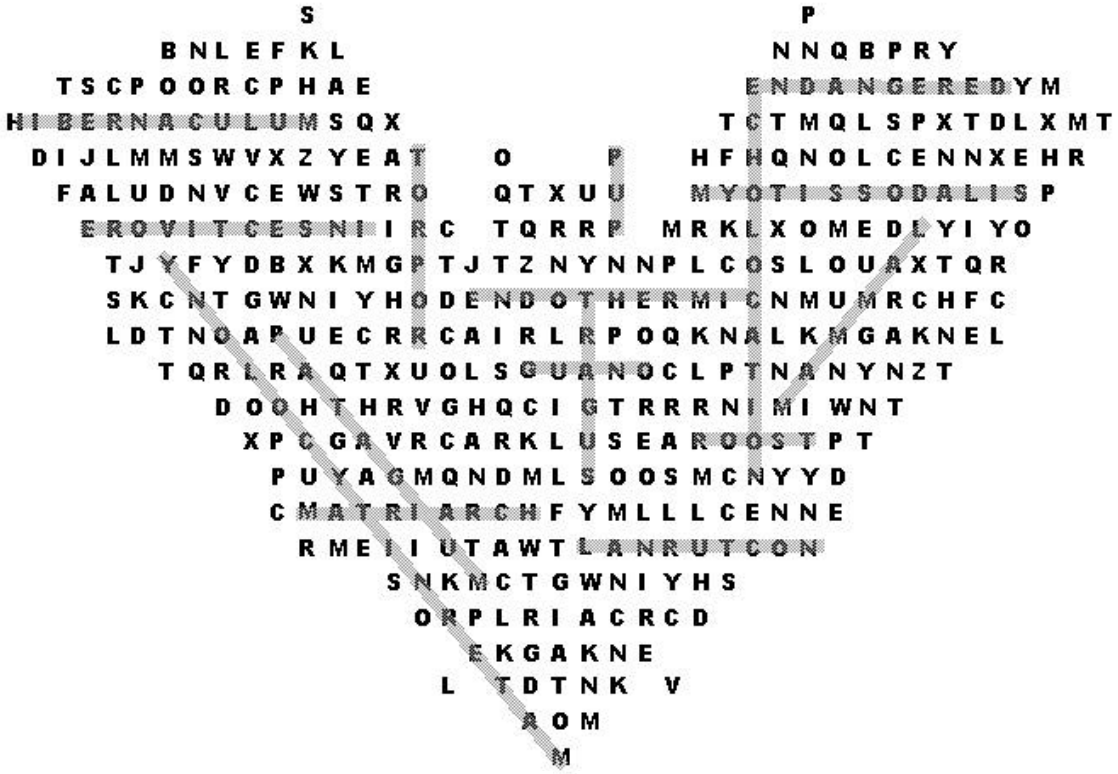
_____ bats

11 Chiroptera Chat

Bat Vocabulary

Materials: Vocabulary List ● Word Search ● Pens and/or Pencils

Students should solve the word search using words from the Bat Vocabulary list.



1. Mammal
2. Pup
3. Endothermic
4. Patagium
5. Echolocation
6. Maternity Colony
7. Tragus
8. Endangered
9. Nocturnal
10. Hibernation
11. Matriarch
12. Guano
13. Insectivore
14. Myotis sodalis
15. Torpor
16. Roost

Name _____

11 Chiroptera Chat

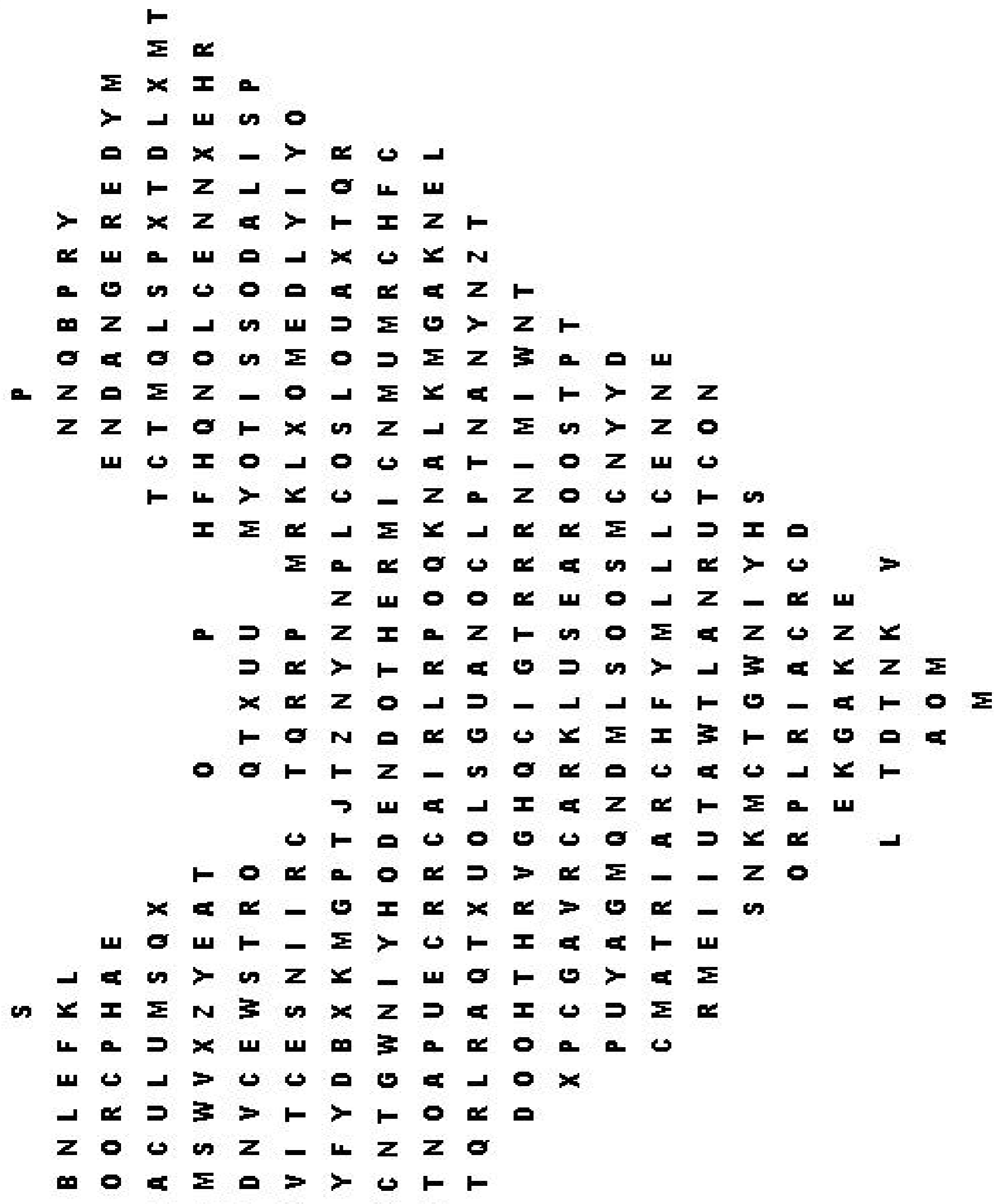
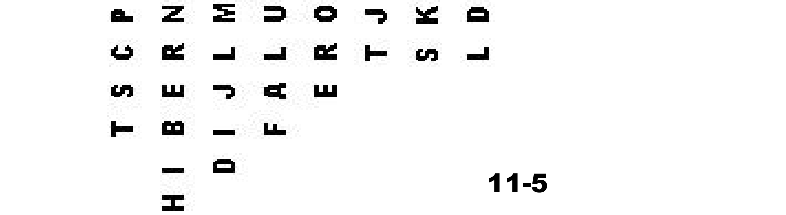
Bat Vocabulary

Echolocation	A type of sonar system used by bats to navigate and to find food.
Endangered	Animals or plants that are at risk of going extinct.
Endothermic	Warm-blooded; warming up the body by an internal source of heat – energy from food.
Guano	Bird or bat droppings, often used as fertilizer.
Hibernaculum	A special roost used for hibernation.
Insectivore	An animal that eats insects.
Mammal	An animal that is warm-blooded, gives birth to live young, has hair, nurses the young with milk from mammary glands, and has a back-bone.
Maternity colony	A special colony established by female bats in which to birth and raise the young.
Matriarch	A female who rules or dominates her family and descendants.
Myotis sodalis	The scientific name of the Indiana bat.
Nocturnal	To be active at night.
Patagium	A very strong layer of skin streatched across a bat's forearms and hands to form wings.
Pup	A baby bat.
Roost	A place where bats sleep, rest while hunting, feed their young, and wait for the optimal time to forage.
Torpor	A deep sleep that usually involves a significant decrease in bodily functions such as breathing and metabolism.
Tragus	An extra flap of skin located at the base of the ear that helps bats hear very quiet sounds.

Name ________________________________

Chiroptera Chat

Fill in the answers to the clues on page 11-6, then circle the words on the bat below.

Name _____

Chiroptera Chat

Fill in the answers to the clues below, then circle the answers on the bat word search on page 11-3.

1.__ __ __ __ __ __ 1. An animal that is warm-blooded, gives birth to live young, nurses them with milk, and has hair and a backbone.

2.__ __ __ 2. A baby bat.

3.__ __ __ __ __ __ __ __ __ __ __ 3. Warming up the body by an internal source of heat.

4.__ __ __ __ __ __ __ __

4. A very strong layer of skin stretched across a bat's forearms and hands to form wings.

5.__ __ __ __ __ __ __ __ __ __ __ __

5. A type of sonar system used by bats to navigate and to find food.

6. __ __ __ __ __ __ __ __ __ 6. A special colony in which to give birth and raise the young.

__ __ __ __ __ __

7. __ __ __ __ __ __ 7. An extra flap of skin at the base of the ear that helps bats hear very quiet sounds.

8. __ __ __ __ __ __ __ __ __ __ 8. Animals or plants that are at risk of going extinct.

9. __ __ __ __ __ __ __ __ __ 9. To be active at night.

10.__ __ __ __ __ __ __ __ __ __ __ __ 10. A special roost used for hibernation.

11.__ __ __ __ __ __ __ __ __ 11. A female who rules or dominates her family and descendants.

12.__ __ __ __ __ 12. Bat droppings.

13.__ __ __ __ __ __ __ __ __ __ __ 13. An animal that eats insects.

14.__ __ __ __ __ __ __ __ __ __ __ __ __ 14. Scientific name of the Indiana bat.

15.__ __ __ __ __ __ 15. A deep sleep that usually involves a significant decrease in bodily functions such as breathing and metabolism.

16.__ __ __ __ __ 16. A place where bats sleep and rest while hunting

12 The Wing's The Thing

Bat Anatomy

Materials: Worksheet ● Pencils ● Glossary or research materials

The purpose of this activity is to learn the names for various parts of a bat's anatomy. You may have your students put the underlined words from the paragraph on page 12-3 into the boxes on the bat illustration, or you may have them research to find the answers to fill in the blanks on page 12-4 before entering the words into the boxes.

Answers:

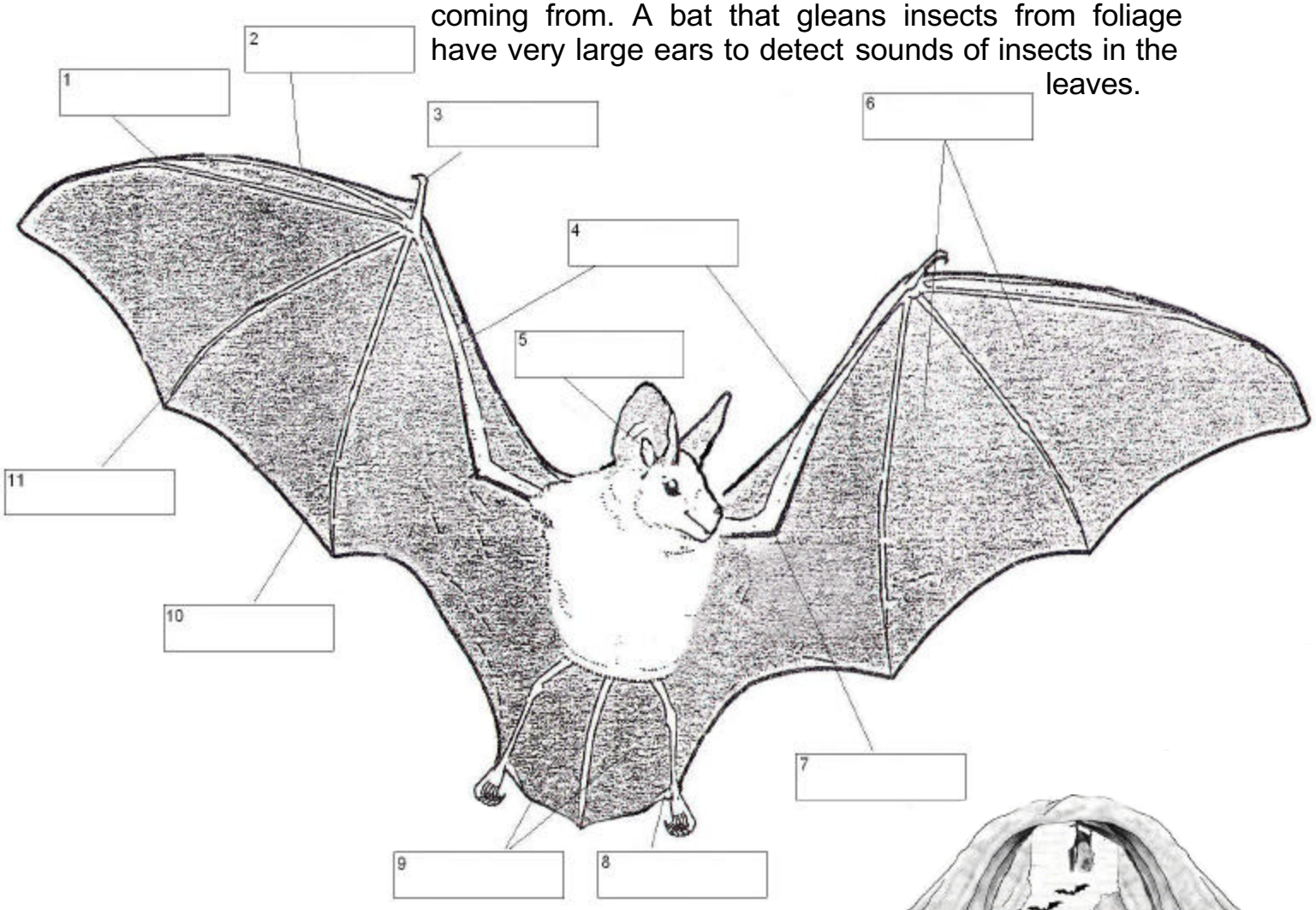
1. Finger
2. Finger
3. Thumb
4. Arms
5. Tragus
6. Patagium
7. Elbow
8. Calcar
9. Uropatagium
10. Finger
11. Finger

Name _____

12 The Wing's The Thing

Read the following paragraph and enter the underlined words into the appropriate boxes on the bat illustration. At least one of the words will be used more than once.

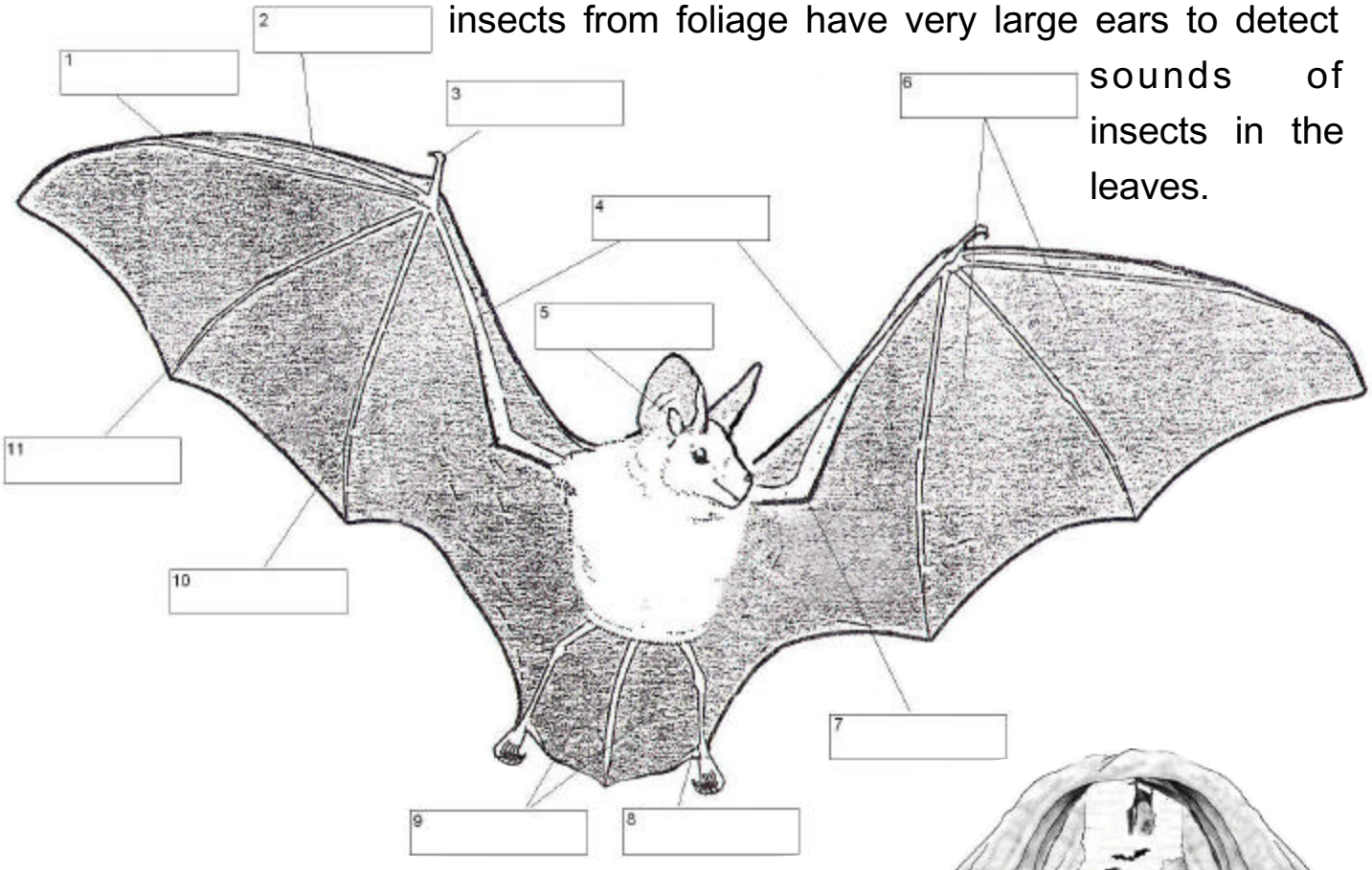
The order bats belong to, Chiroptera, means "hand-wing" in Greek. Bats were given this name because their wings are modified hands. They are made up of their *arm*, four *finger*s and a *thumb* connected by skin called the *patagium*. The patagium expands when the wings are extended and contracts when they are at rest. By contracting the patagium and flexing their *elbows*, bats can run nimbly across the ground on their thumbs and feet. Some bats use their *calcar*s, a spur made of cartilage on it's foot, and *uropatagium* as a net to scoop up insects for dinner. Bats that use echolocation to find insects in the air, have an ear and *tragus* that are shaped to detect the direction sounds are coming from. A bat that gleans insects from foliage have very large ears to detect sounds of insects in the leaves.



Name _____

12 The Wing's The Thing

The order bats belong to, Chiroptera, means "hand-wing" in Greek. Bats were given this name because their wings are modified hands. They are made up of their (a)_____, four (b)_____ and a (c)_____ connected by skin called the (d)_____. The patagium expands when the wings are extended and contracts when they are at rest. By contracting the patagium and flexing their (e)_____, bats can run nimbly across the ground on their thumbs and feet. Some bats use their (f)_____, a spur made of cartilage on it's foot, and (g)_____ as a net to scoop up insects for dinner. Bats that use echolocation to find insects in the air, have an ear and (h)_____ that are shaped to detect the direction sounds are coming from. A bat that gleans insects from foliage have very large ears to detect sounds of insects in the leaves.



13 Bats of Indiana

Playing Card Activities

Materials: Multiple copies of bat card pages (front and back), preferably on cover stock ● Crayons, colored pencils or markers and scissors ● laminate (optional)

Have each student color and cut out a set of cards. If possible, laminate the cards. Following are some card game suggestions to help familiarize students with characteristics of the different types of bats found in Indiana.

Bat Rummy

Several students can play this game using multiple sets of bat cards. Each player gets 5 cards to start; remaining cards should be placed in the middle, face down, with the top card face up beside the deck forming the discard pile. The object of the game is to dispose of all your cards before anyone else. Players take turns. When it is your turn, you must take one card from the middle: either one from the top of the deck, or the one on top of the discard pile. You should then lay down (face up) groups of cards you have in your hand (if any); anytime you have more than one card of any bat, that is considered a group. You then must discard one card in the discard pile and your turn is over. On future turns, you may add to the groups of cards you have in front of you, but you may not add to anyone else's groups. The player who discards all cards first wins.

Bat Trivia

Two or more teams can play this game using one set (or more) of bat cards. Team #1 draws a card from the pile. Team #2 picks a category (diet, reproduction, summer roost, winter habit, status, or fascinating fact). Team #1 reads the category information from the back of the card and Team #2 must determine which bat it is. If they know, they receive 5 points and get another turn. If they don't know, they may ask to have another category read. If they then get the answer, they receive 2 points, but do NOT get another turn. Teams play to a pre-determined point value or for a specified amount of time, and the team with the most points wins. Once students are knowledgeable, make the game harder by forbidding use of the fascinating fact in the game, or by allowing only 1 point if the fascinating fact is used to determine the type of bat.

Go Bat! (Variation on Go Fish!)

The object of this game is to collect books, or six cards of the same type of bat, by asking other players for cards you think they might have. The player who collects the most books wins. Three to six students can play this game with multiple sets of bat cards. Deal the cards until all players have the same number (or close to the same number) of cards. One player starts by asking any other player for a particular type of bat. For example, player #1 might say "Mary, do you have any Hoary Bats?" The player doing the asking must always have at least one of the bat he/she is asking for, and must show it as proof. If Mary has any Hoary Bats, she must give ALL of them to player #1. Player #1 then gets another turn, and asks someone else for a type of bat. This continues until the player asks someone for a type of bat which they don't have. That person then says "Go Bat!" and it becomes his or her turn. Any books formed should be put down face up as they are formed. When someone runs out of cards, the game is over, and the person with the most books wins.

BIG BROWN BAT

Status: Common

Diet: Mostly beetles, flying ants, stinkbugs mayflies, stoneflies, caddisflies, brown lacewings

Foraging: Some use the same feeding ground each night

Summer Roost: Hollow trees, man-made structures
Winter Habit: hibernate in caves/mines or remain in summer roosts with stable temperatures
Reproduction: Twins early June
Size/Appearance: 11-23 grams, 32-35 cm wing span
Fascinating Fact: Females are larger than males and can force them out of prime roosting sites

SILVER-HAIRED BAT

Status: Relatively rare
Diet: moths, true bugs, flies, termites, beetles
Foraging: Over woodland ponds and streams
Summer Roost: loose tree bark, open buildings
Winter Habit: hibernate in protected shelters like rock crevices or buildings
Reproduction: Twins early summer
Size/Appearance: 8-11 grams, 27-32 cm wingspan
Fascinating Fact: One of the slowest flying bats in North America

HOARY BAT

Status: Uncommon

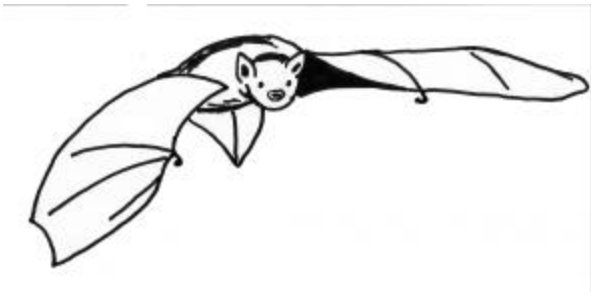
Diet: primarily moths, beetles, stinkbugs, rarely small rodents and other bats

Foraging: warm winter afternoons

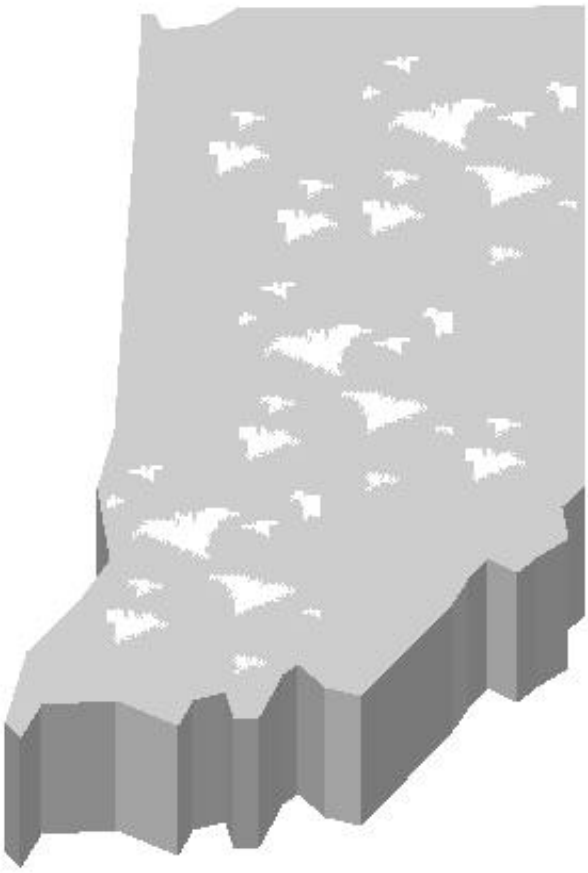
Summer Roost: tree foliage at edge of clearings

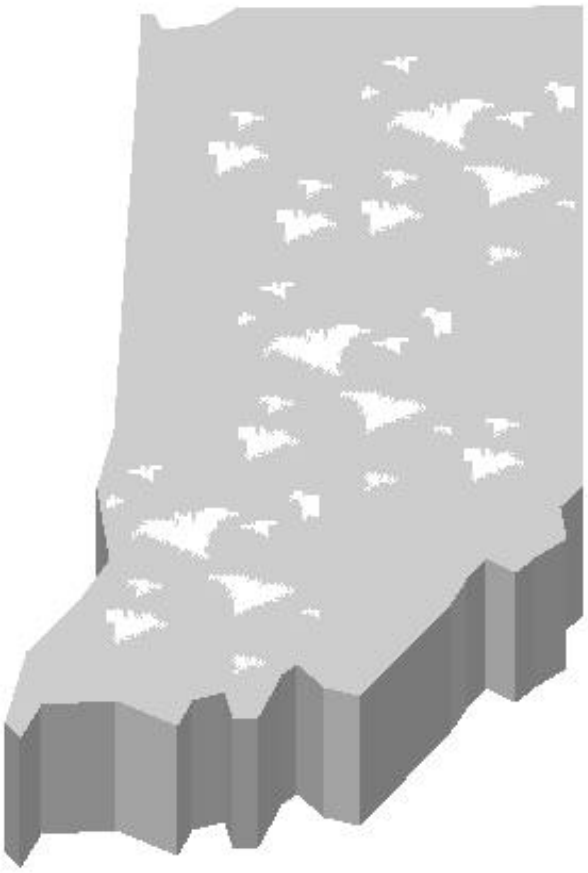
Winter Roost: northern populations migrate; may wander into caves in late summer
Reproduction: Twins (early summer) cling to mother's fur
Size/Appearance: 17-35 grams, 38-41 cm wing span, heavily furred
Fascinating Fact: Males spend summer west of Rockies, females east of Rockies

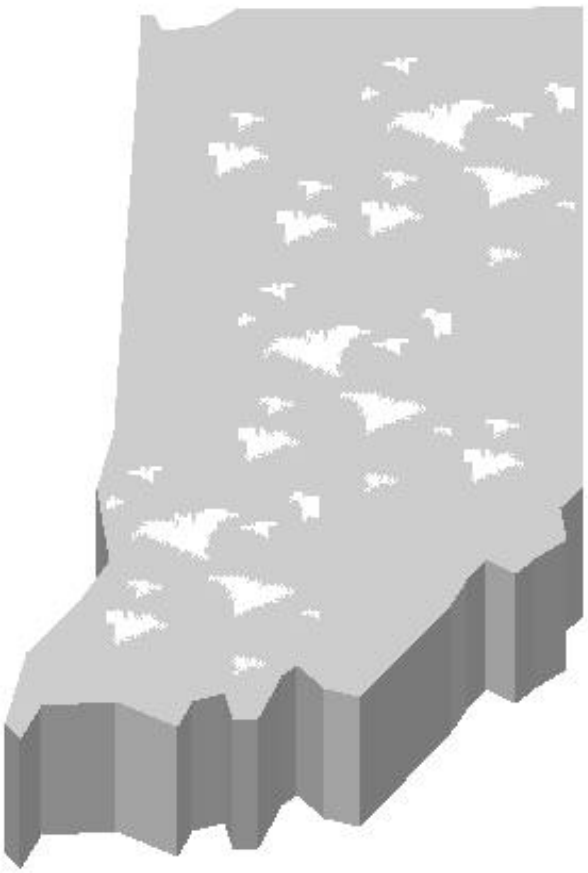
GRAY BAT

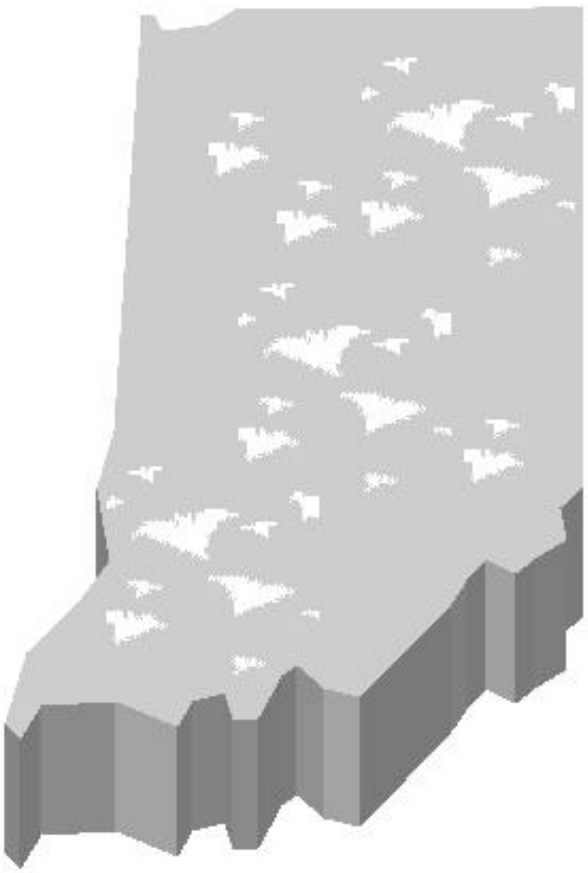


Status: Endangered
Diet: stoneflies, caddisflies, mayflies, Asiatic oak weevils, true flies, beetles
Foraging: Over rivers and lakes
Summer Roost: Maternity colonies in caves that trap warm air
Winter Habit: Hibernate in deep vertical caves with large rooms that trap cold air
Reproduction: One pup late spring
Size/Appearance: 8-11 grams, 27-30 cm wingspan
Fascinating Fact: 95% hibernate in only eight caves

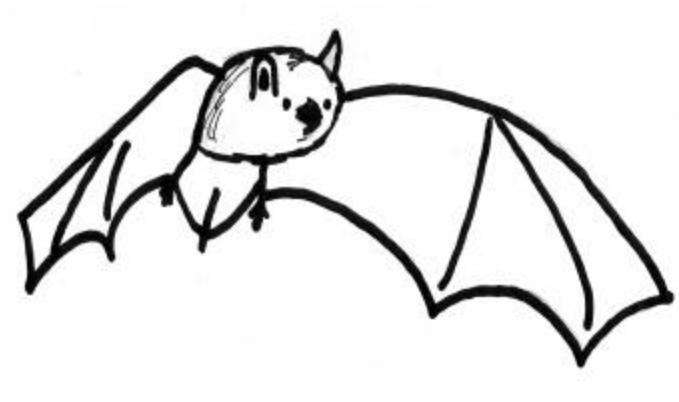








SOUTHEASTERN BAT



Status: Rare, endangered listing has been proposed
Diet: unknown - probably aquatic insects
Foraging: close to surface of water
Summer Roost: Maternity colonies in caves or buildings
Winter Habit: small groups at outdoor sites
Reproduction: Twins in spring
Size/Appearance: 5-8 grams, 24-27 cm wingspan
Fascinating Fact: the only bat of the genus *Myotis* that produces twins

LITTLE BROWN BAT

Status: Common
Diet: gnats, moths, true bugs, caddisflies, beetles
Foraging: prefers over water
Summer Roost: Hot buildings for large nursery colonies
Winter Habit: hibernates in caves or mines
Reproduction: One pup in spring or early summer
Size/Appearance: 7-14 grams, 22-27 wingspan
Fascinating Fact: captures insects with wing tip and scoops into mouth with help of tail.

INDIANA BAT

Status: Endangered

Diet: moths, beetles, flies, caddisflies, ants, stoneflies, true bugs

Foraging: river and lake shorelines and upland forests near roosts

Summer Roost: maternity roosts under loose tree bark in stream-side habitat

Winter Habit: hibernate in dense clusters in caves

Reproduction: One pup in June

Size/Appearance: 7-8 grams, 24-27 wingspan

Fascinating Fact: 85% hibernate in only nine locations

RAFINESQUE'S BIG-EARED BAT

Status: Uncommon

Diet: moths and other night-flying insects

Foraging: late evening (rather than twilight)

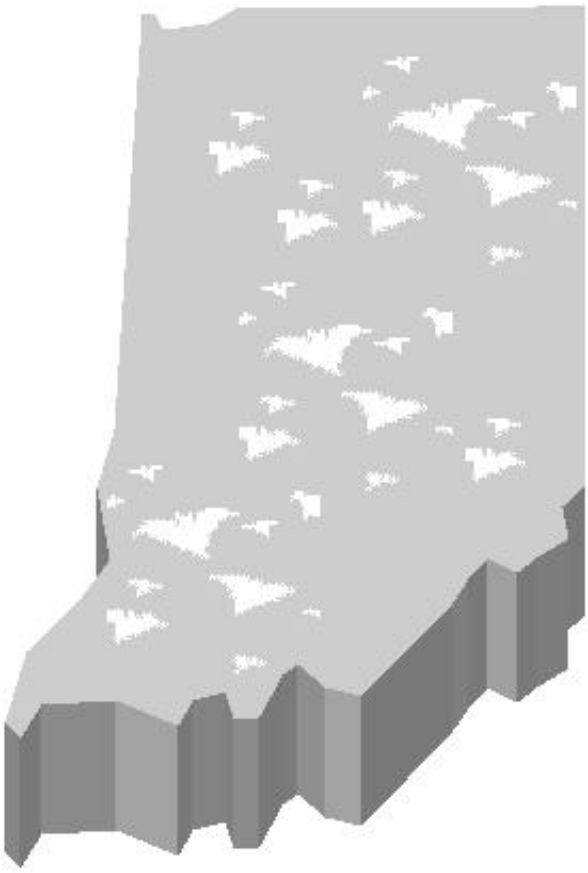
Summer Roost: maternity colonies in abandoned buildings

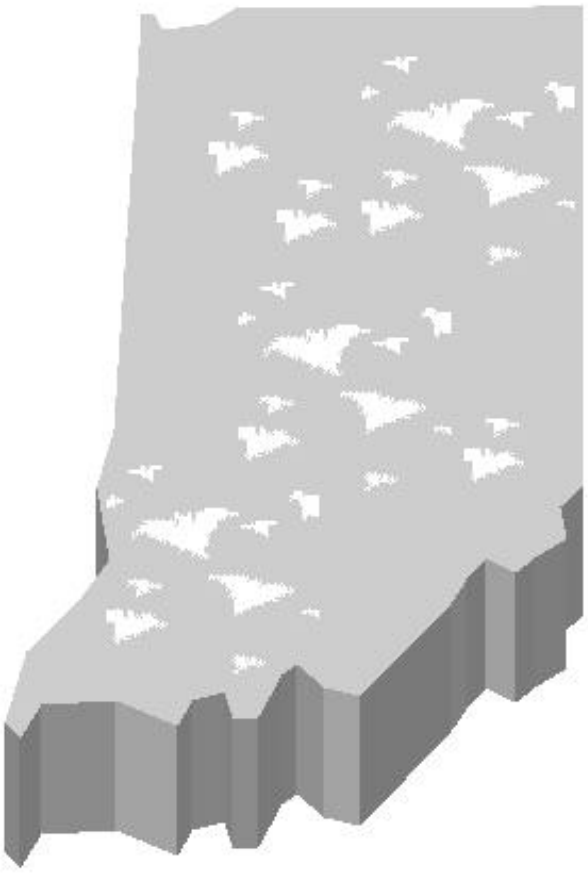
Winter Habit: hibernates in caves, mines, wells cisterns

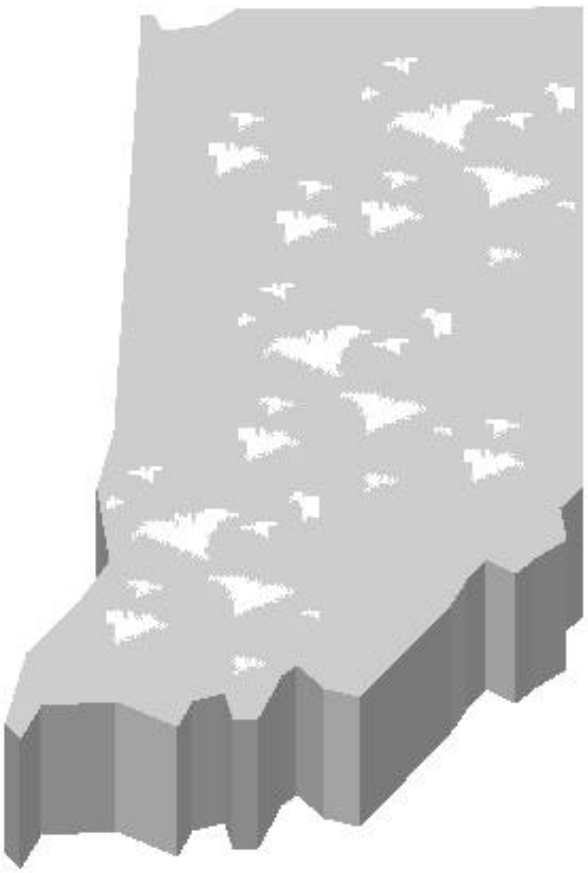
Reproduction: one pup late spring

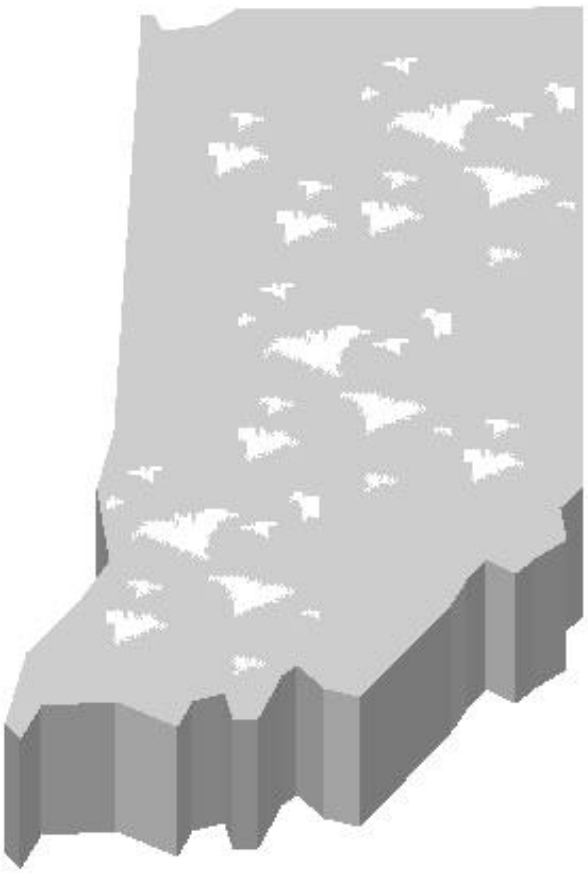
Size/Appearance: 8-14 grams, 26-30 cm wingspan

Fascinating Fact: They roll their ears up at rest. The rolled ears sit at the base of their neck like ram's horns.









EASTERN PIPISTRELLE BAT

Status: Common
Diet: tiny flies, moths, beetles, wasps, ants
Foraging: over waterways and around forests edges
Summer Roost: In trees, sometimes caves at night
Winter Habit: hibernates in caves, mines and rock crevices
Reproduction: Twins late spring or early summer
Size/Appearance: 5-8 grams, 21-26 cm wingspan
Fascinating Fact: Individual bats often hibernate in the exact same spot in a cave every year

NORTHERN LONG-EARED BAT

Status: Uncommon
Diet: various flies, moths, beetles, spiders, true bugs, caddisflies
Foraging: On forested hillsides and ridges
Summer Roost: daytime in buildings or under tree bark, nights in caves
Winter Habit: hibernates in caves/mines
Reproduction: one pup June or July
Size/Appearance: 6-97 grams, 22-26 cm wingspan
Fascinating Fact: Hibernate deep in crevices.

EVENING BAT

Status: Uncommon

Diet: beetles (especially spotted cucumber beetles), moths, leafhoppers, stinkbugs, chinchbugs

Foraging: semi-open habitats from wetlands to woodlands

Summer Roost: tree cavities or buildings

Winter Habit: unknown; builds up fat reserves sufficient for hibernation or migration

Reproduction: Twins late spring

Size/Appearance: 7-14 grams, 26-28 cm wingspan

Fascinating Fact: Swarms with other bats around cave entrances in late summer, but does not enter the caves

EASTERN RED BAT

Status: Common

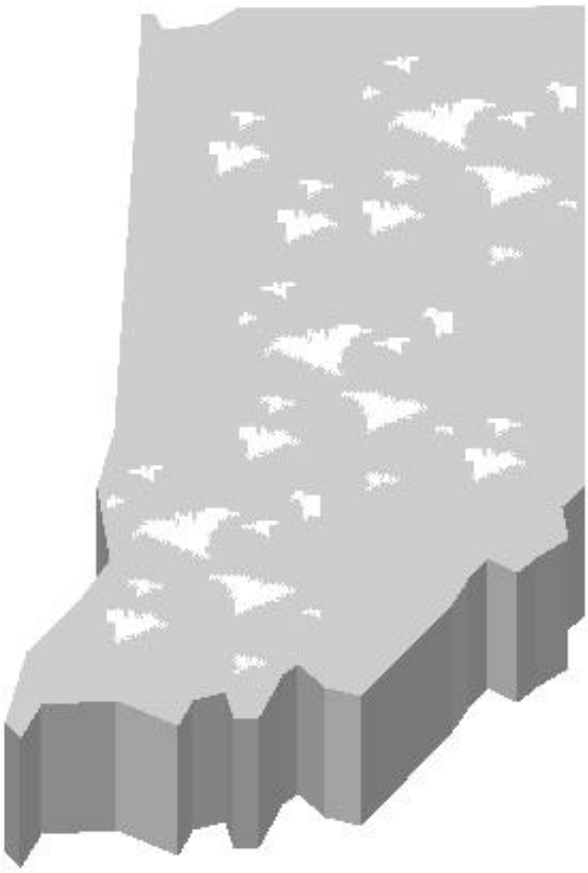
Diet: moths, June bugs, ants, planthoppers, leafhoppers, beetles

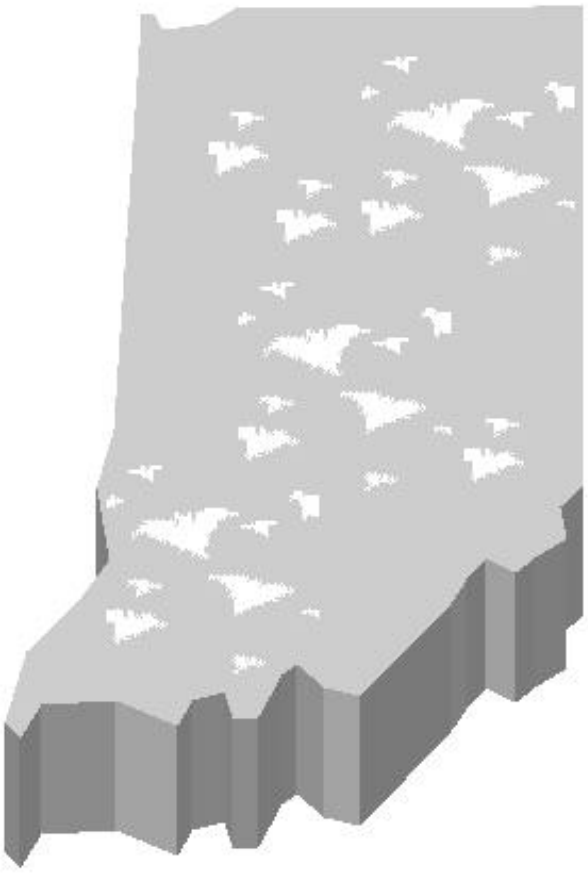
Foraging: early evening, warm winter afternoons, under street lights

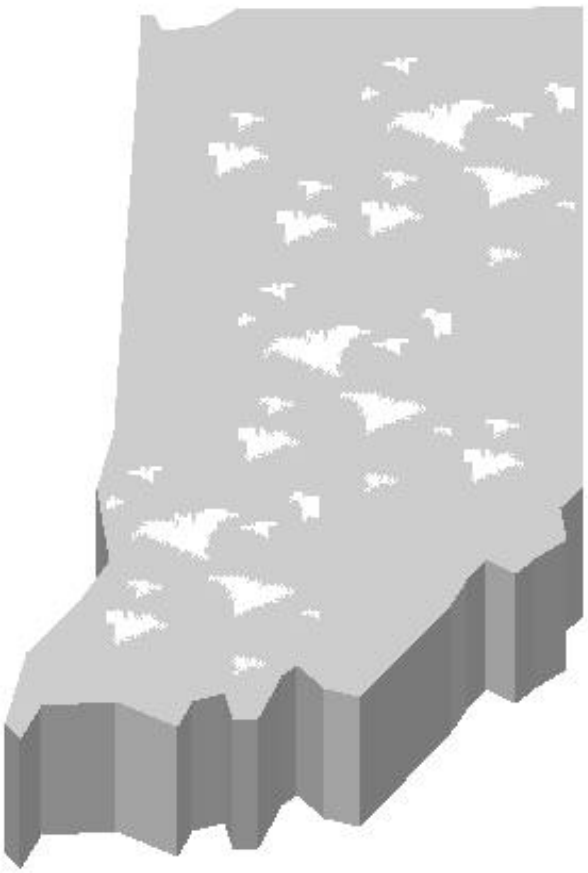
Summer Roost: Hangs from trees

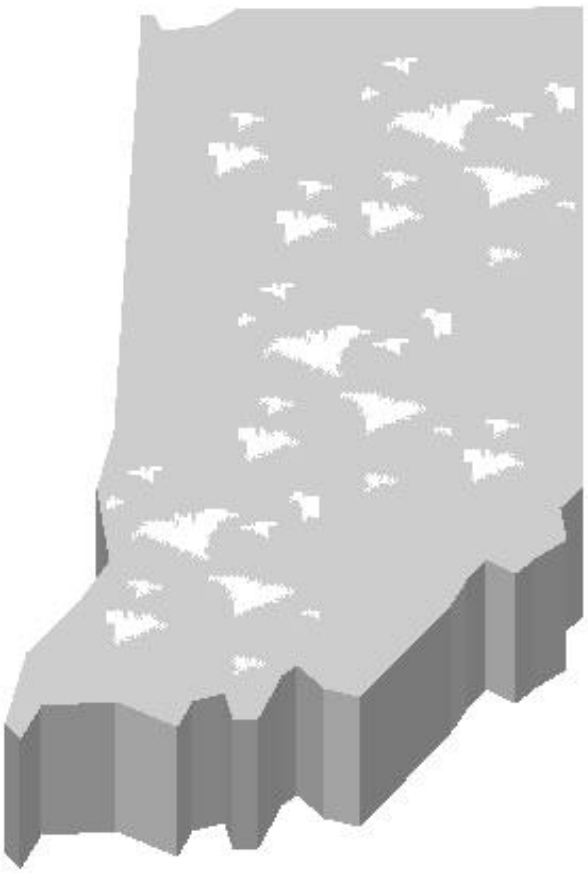
Winter Habit: Migrate south or hibernate in hollow trees or leaf litter

Reproduction: One to four pups (late spring) cling to mother's fur
Size/Appearance: 8-14 grams, 29-33 cm wing span, fur
Fascinating Fact: Hang from trees by one foot to camouflage as dead leaves









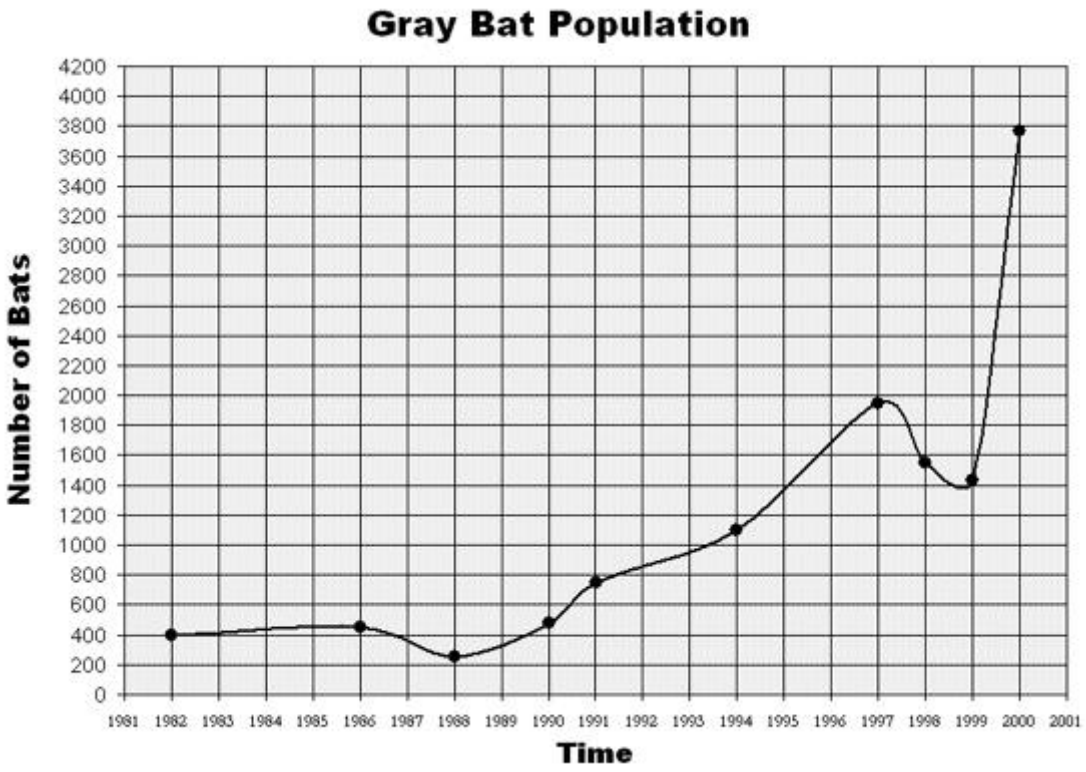
14 Plotting Populations

Graph Drawing Activity

Materials: Plotting Populations Worksheet ● Markers, crayons, &/or colored pencils ● Large sheet of graph paper (Optional)

Students should graph the data concerning grey bat populations at a single colony in Clark County, Indiana and answer the questions based on their graphs. As an option, the class can do the graphing and/or the questions as a group.

Answer Key



1. The colony has increased 942% since 1982.
2. At least three times
3. Approximately 1400 bats
4. Between 1988 and 1990 (Actually in 1990)

Name _____

14 Plotting Populations

Using the data in the table below, make a graph illustrating the changes in a gray bat population at a single colony in Southern Indiana. Don't forget to label your graph. Use the graph you've create to answer the questions on the next page.

Grey Bat Populations (Clark Co, Indiana)

Year	1982	1986	1988	1990	1991	1994	1997	1998	1999	2000
Number of Bats	400	453	253	481	752	1101	1949	1552	1430	3768

Name _____

14 Plotting Populations pg. 2

1. This colony has increased _____% since 1982.

   a) 9.42% b)842% c) 942% d) 442%

2. How many times has the population decreased since it started being measured in 1982?

3. The colony was not measured in 1995. Using your graph, estimate how many bats were in the colony that year.

4. When do you think this colony started being protected?

15 Indiana Bats and Me

Measurement Activity

Materials: Copies of Worksheet ● Stopwatches or clock with second hand ● Weight scale for humans ● Gram scale ● Tape measures and Yardsticks (metric and standard) ● Variety of coins ● Optional: calculators

Students can learn a great deal about Indiana 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 Indiana bats.

Background Information & Answer Key

Mammals

Even though Indiana 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.

Wingspan

Indiana bat wingspans vary from about 24-28 centimeters, or about 9-11 inches. Have students stretch out their arms and measure the distance between fingertips.

Number of Fingers

A bat's wing is actually a modified hand. (Refer to the attached diagram and explain how the wing bones are actually greatly elongated fingers. Also point out the thumb. The thumb has a small claw which aids the bat in crawling around on rough surfaces.

Weight

Have students get on a scale and take their own weight. The Indiana bat weighs only about one quarter of an ounce, or between 6 and 9 grams. Have students experiment with coins and the gram scale to find the weight of an Indiana bat in coins. This helps students better visualize how very tiny the Indiana bat is.

Height

Have students work in pairs to measure their height in inches.

Resting Heart Rate
Using a clock with a second hand or a stopwatch, demonstrate to students how to find their pulse (by putting your fingers against the carotid artery in the neck). Sitting down, students should take a resting pulse by counting the number of heart beats in a 15-second period and multiplying this by four to determine the total for one minute.

Active Heart Rate
Before taking this rate, have students simulate flight by doing one minute of jumping jacks. Immediately following this, they take their pulse again using the method described above. The bat's heart rate is high because flight is hard work. Its heart must pump rapidly to provide lots of oxygen, which is carried to flight muscles by blood. During hibernation, the opposite extreme, a bat's heart rate slows to only 20 heartbeats per minute.

Wing Beats
To determine wing beats per second, have the students flap their arms like wings and count the number they can do in five seconds. The teacher then divides that number by five to find the rate per second. 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.

Food Consumption
The teacher may need to help students determine this number (1/32 of a student's weight). Indiana bats eat about half their body weight in insects each night. Have students figure out how much they would have to eat in one day if they ate half their body weight. How many "quarter-pounders" would they have to eat??

Lifespan
The average lifespan for a human is 74 years. Indiana bats live an average of 5-10 years, although some individuals can live up to 14 years. For their size, bats are among the longest-lived animals. For comparison, most mice have a lifespan of only about two years.

Name _____

How an Indiana Bat Compares to Me

	Student	Indiana Bat
Kind of Animal	_____	Mammal
Wingspan/Armspan	_____	9-11 in/24-28 centimeters
Number of Fingers	_____	four fingers, one thumb
Weight	_____	approx 1/4 ounce 0.2-0.3 ounce/6-9 grams
Height	_____	about 2 inches
Heart Beats/Minute Resting	_____	less than 100*
Heart Beats/Minute Active	_____	as many as 900*
Wing Beats/Second	_____	about 12**
Food Consumption	_____	1/2 body weight per night
Lifespan	_____	5-10 yrs average, 14 possible

* Statistics for small bats in general
** Statistics for Little Brown Bat

Bats at Risk

Threats facing Indiana Bats

Materials: Research materials: magazines, encyclopedias, internet, etc. ● poster board ● markers ● construction paper ● other poster-making supplies

Indiana bats have been on the Federal Endangered Species list since 1967. Unfortunately the current population (about 457,000 in 2005) is about half as many bats as when the species was initially listed. The following summary is from the US Fish and Wildlife Services fact sheet for the Indiana bat (http://www.fws.gov/midwest/endangered/mammals/inbafctsht.html)

Why is the Indiana Bat Endangered?

Human Disturbance
Indiana bats, because they hibernate in large numbers in only a few caves, are extremely vulnerable to disturbance. During hibernation, they cluster in groups of up to 500 per square foot. Since the largest hibernation caves support from 20,000 to 50,000 bats, it is easy to see how a large part of the total population can be affected by a single event. Episodes of large numbers of Indiana bat deaths have occurred due to human disturbance during hibernation.

Cave Commercialization and Improper Gating
The commercialization of caves – allowing visitors to tour caves during hibernation – drives bats away. Changes in the structure of caves, such as blocking an entrance, can change the temperature in a cave. A change of even a few degrees can make a cave unsuitable for hibernating bats. Some caves are fitted with gates to keep people out, but improper gating that prevents access by bats or alters air flow, temperature, or humidity can also be harmful. Properly constructed gates are beneficial because they keep people from disturbing hibernating bats while maintaining temperature and other requirements and allowing access for bats.

Summer Habitat Loss or Degradation
Indiana bats use trees as roosting and foraging sites during summer months. Loss and fragmentation of forested habitats can affect bat populations.

Pesticides and Environmental Contaminants
Insect-eating bats may seem to have an unlimited food supply, but in local areas, insects may not be plentiful because of pesticide use. This can also affect the quality of the bats' food supply. Many scientists believe that population declines occurring today might be due, in part, to pesticides and environmental contaminants. Bats may be affected by eating contaminated insects, drinking contaminated water, or absorbing the chemicals while feeding in areas that have been recently treated.

What is Being Done to Prevent Extinction of the Indiana Bat?

Listing
Prompted by declining populations caused by disturbance of bats during hibernation and modification of hibernacula, the Indiana bat was listed in 1967 as "in danger of extinction" under the Endangered Species Preservation Act of 1966. It is listed as "endangered" under the current Endangered Species Act of 1973. Listing under the Endangered Species Act protects the Indiana bat from take (harming, harassing, killing) and requires Federal agencies to work to conserve it.

Recovery Plan
The Endangered Species Act requires that recovery plans be prepared for all listed species. The U.S. Fish and Wildlife Service developed a recovery plan for the Indiana bat in 1983 and is now revising that Plan. The recovery plan describes actions needed to help the bat recover.

Habitat Protection
Public lands like National Wildlife Refuges, military areas, and U.S. Forest Service lands are managed for Indiana bats by protecting forests. This means ensuring that there are the size and species of trees needed by Indiana bats for roosting; and providing a supply of dead and dying trees that can be used as roost sites. In addition, caves used for hibernation are managed to maintain suitable conditions for hibernation and eliminate disturbance.

Education and Outreach
Understanding the important role played by Indiana bats is a key to conserving the species. Helping people learn more about the Indiana bat and other endangered species can lead to more effective recovery efforts.

Revised December 2006

Activity:

There are many ways people can help the Indiana bat. For this activity, students should:

- research why Indiana bats are endangered and things they can do to help.
- design and make posters showing ways Indiana bats can be helped.

Share with the students that their posters can be part of the education and outreach program. Hang them in the classroom or school.

Extension Activity: Raise funds as a class for the construction of cave gates or other bat conservation projects.

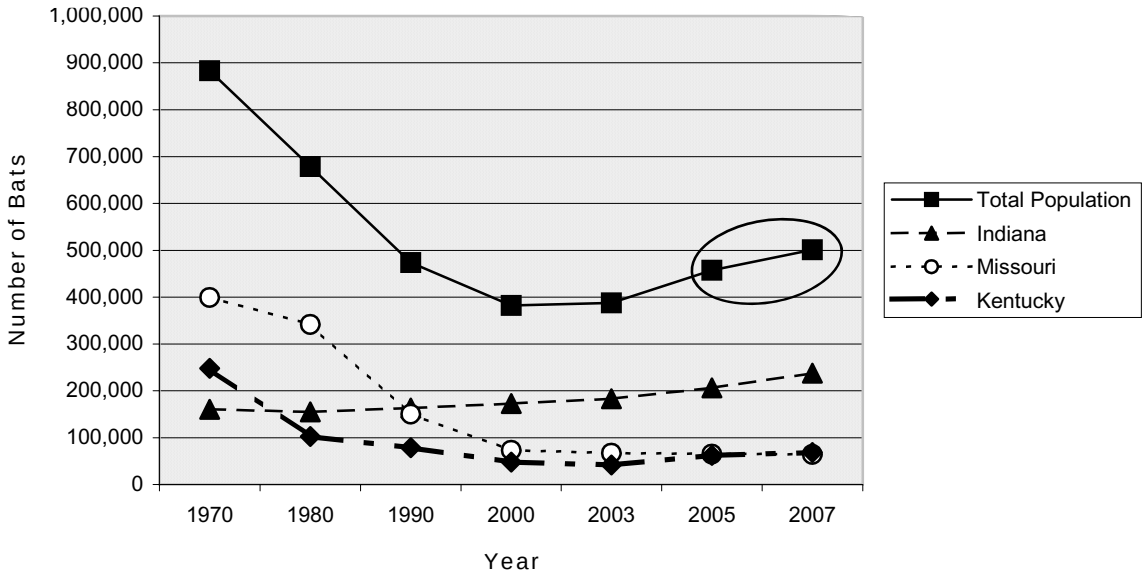
Decades of Decline

Graph Interpretation

Materials: Decades of Decline Worksheet ● Pens &/or pencils

Students should use the following graph to answer questions regarding selected state and national trends for Indiana bat populations. Please note that populations were surveyed at hibernacula and that some population estimates were based on surveys done near the year indicated. Long term data was taken from Clawson (2002) and figures for 2003—2007 were provided by United States Fish and Wildlife Service, Bloomington Field Office. As of this writing, it is estimated that the state of Indiana hosts almost half the total population of hibernating Indiana bats.

State and National Trends for Indiana Bats



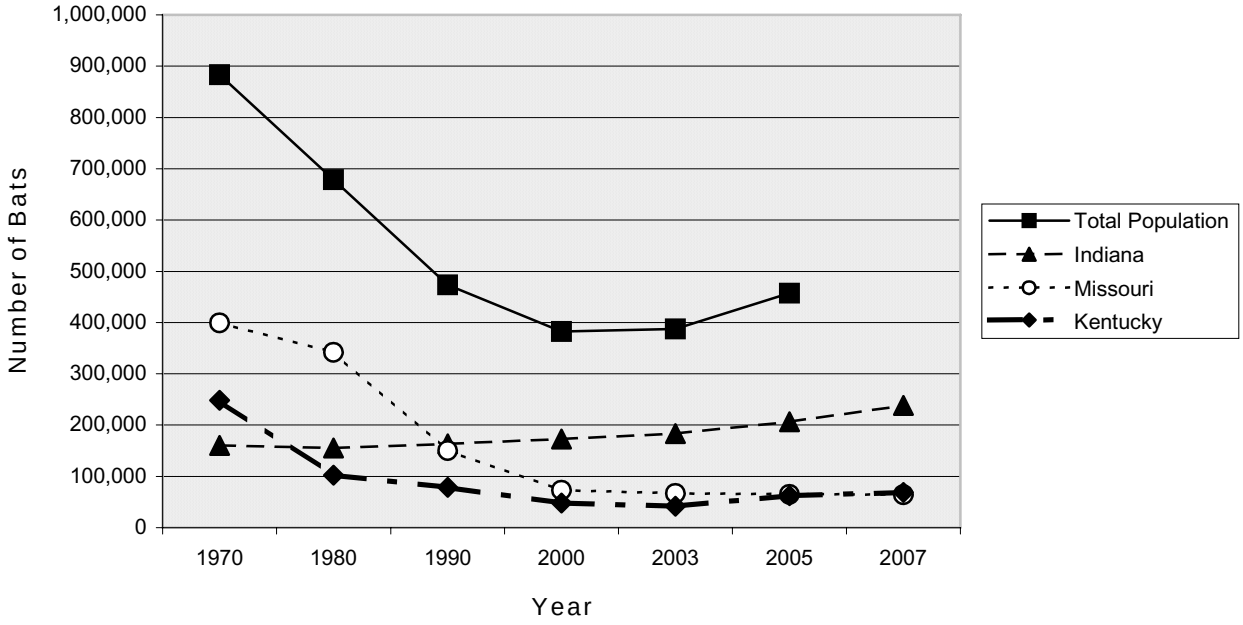
Answer Key

1. c) Declined
2. a) Missouri
3. About 1 in 2
4. In the eighties
5. Indiana bat populations would drop sharply to about 150 - 200,000 individuals (i.e. lose half the population).
6. See circled area on graph above.

Name _____

17 Decades of Decline

State and National Trends for Indiana Bats



Using the graph, answer the following questions about hibernating Indiana bat populations in the United States:

1. What has happened to Indiana bat populations in the last thirty years?

   a) Increased b) Stayed Stable c) Declined

2. Which state has had the biggest drop in Indiana bat populations?

   a) Missouri b) Indiana c) Kentucky

Name _____

3. What proportion of Indiana bats in the United States hibernate in the state of Indiana?

a) about 1 in 10 b) about 1 in 4 c) about 1 in 2 d) all of them

4. Using the graph, when do you think Indiana started protecting caves housing hibernating Indiana bats?

a) in the seventies b) in the eighties

c) in the nineties d) in the last decade

5. What would happen to Indiana bat populations if the three major caves in Indiana that house more than 80% of the state's Indiana bats were no longer protected?

6. In 2007, the total population of Indiana bats was estimated at 501,260 individuals. On the graph, plot their total population and draw a line showing the trend.

18 How Many Indiana Bats Can Sleep in a Shoebox?

Spatial Reasoning

Materials: Shoebox ● copies of pg. 18-2 ● crayons or markers ● scissors ●? glue or scotch tape

In October, Indiana bats converge in large caves with specific climatic conditions (low temperatures and high humidity). There may be as many as 125,000 bats per cave. They hibernate in tightly packed clusters, one row deep and so neatly arranged that only the faces, ears and wrists of each bat can be seen. They are squeezed so closely together, that there may be from 300—484 bats in one square foot of cave roof!

Photo: © Richard L. Clawson

To give your students an idea of what this looks like, construct your own bat cluster by making the bat boxes on page 18-2 and placing them into a shoebox.

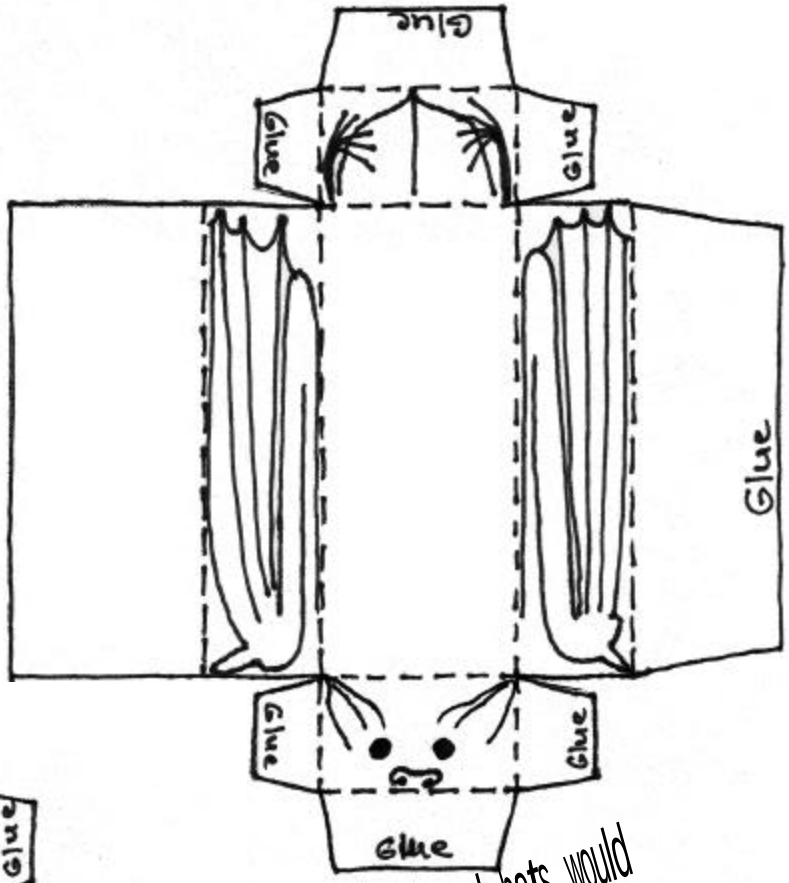
1. Each student should make several bat boxes. The number you need depends on the size of your shoebox. We fit 100-120 in a 5in. X 10in. Box (depending on the directions the bats were facing).
2. Color the bats.
3. Cut them out on the solid lines.
4. Fold on the dotted lines.
5. Glue (or tape) where indicated.
6. The resulting "bat box" is the approximate size on an actual Indiana bat with it's wings folded into it's sides for hibernation.
7. Pack the bats as tightly as you can into a shoebox. The faces should be facing out, and you should pack them only one layer deep.

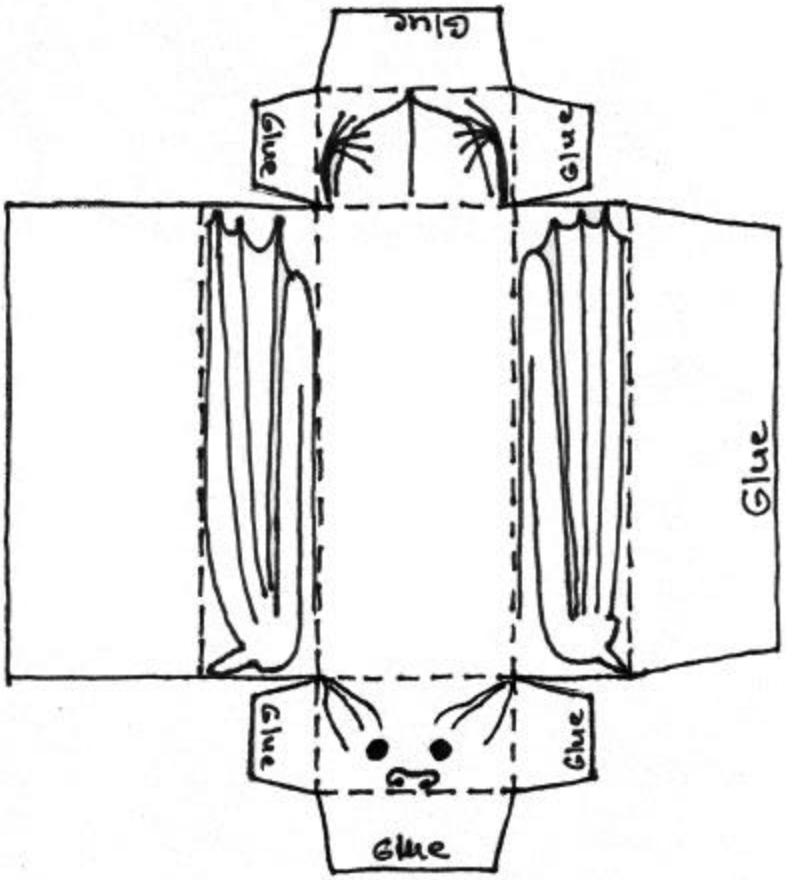
Name _____

18 How Many Indiana Bats Can Sleep in a Shoebox?*

Make bat boxes to determine how many Indiana bats could hibernate in a shoebox.

1. Color the bats.
2. Cut out along the solid lines.
3. Fold along the dotted lines.
4. Glue or tape where indicated.
5. "Hang" your bats with only their faces showing to fill your shoebox.





* Of course, real bats would never live in a shoebox!

Name _____

18 How Many Indiana Bats Can Sleep in a Shoebox?

Answer the following questions about your shoebox full of bats.

1. What size is your shoebox? Give the dimensions.

_____

2. How many bats fit inside your shoebox?

_____

3. Would more or fewer real Indiana Bats fit into that sized space? Why?

_____

4. Think about what it would be like to be so tightly packed together. What happens in the spring when the bats start to wake? Describe what you think happens to its neighbors when a bat wakes and flies away.

19 Voices in the Night

Story Starters

Materials: Pencils ● Notebook Paper ● Story Cards ● Story Paper ● Bat Pattern ● 11x17 Paper or Brown Construction Paper ● Stapler

Students will write a story using one of the story ideas on the Story Cards. You can choose which card to use in many ways:

- Each student gets a copy of the sheet and chooses a story.
- Teacher assigned.
- Glue the story starters to index cards and have students draw one.

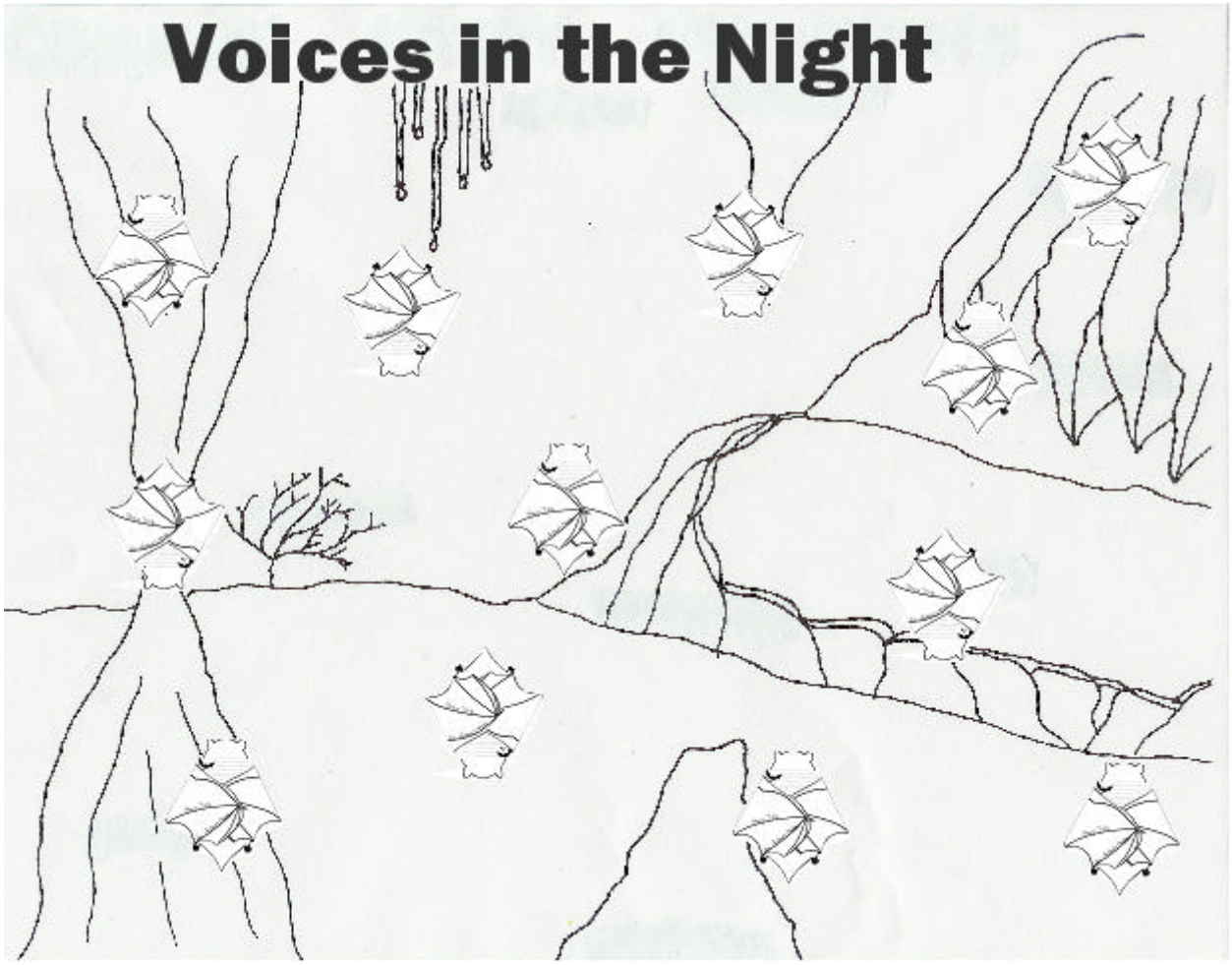
Students should go through each of the steps when writing their stories, including pre-writing, editing and revising. They should then write the final draft of the story on the bat paper. If you would prefer final drafts to be computer generated, the finished copy should measure 4.5” x 7.5”.

After the stories are finished, they should be mounted onto bats. The bat pattern can be traced onto a sheet of 11”x17” paper folded in half. Students should cut out the bat shape and staple their story pages where indicated. The stories can be attached right side up or upside down, depending on whether the student wants his or her bat to be hanging from the ceiling or flying.

Fold the wings over the story on the dotted lines. The title and author’s names should be written on the outside of the wings. The students may wish to draw finger bones. See samples below…

Changing your bulletin board from *Karst in the Classroom* (see Activity 1) to *Voices in the Night*

Remove the letters and the structure labels but keep the cave background. Place the bats with the stories that the students wrote onto the board. Hang bats upside-down or rightside-up so that their story is able to be read.

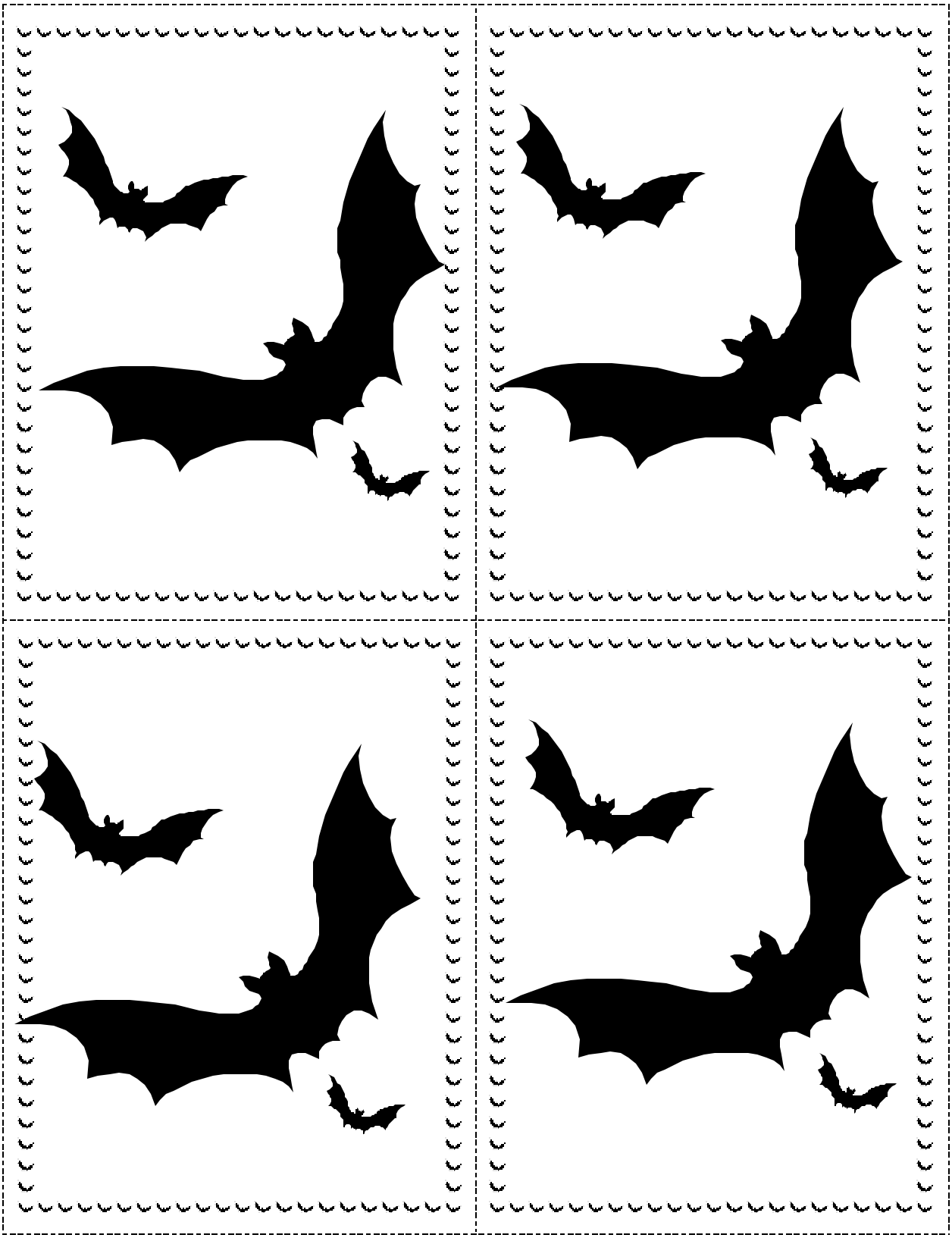


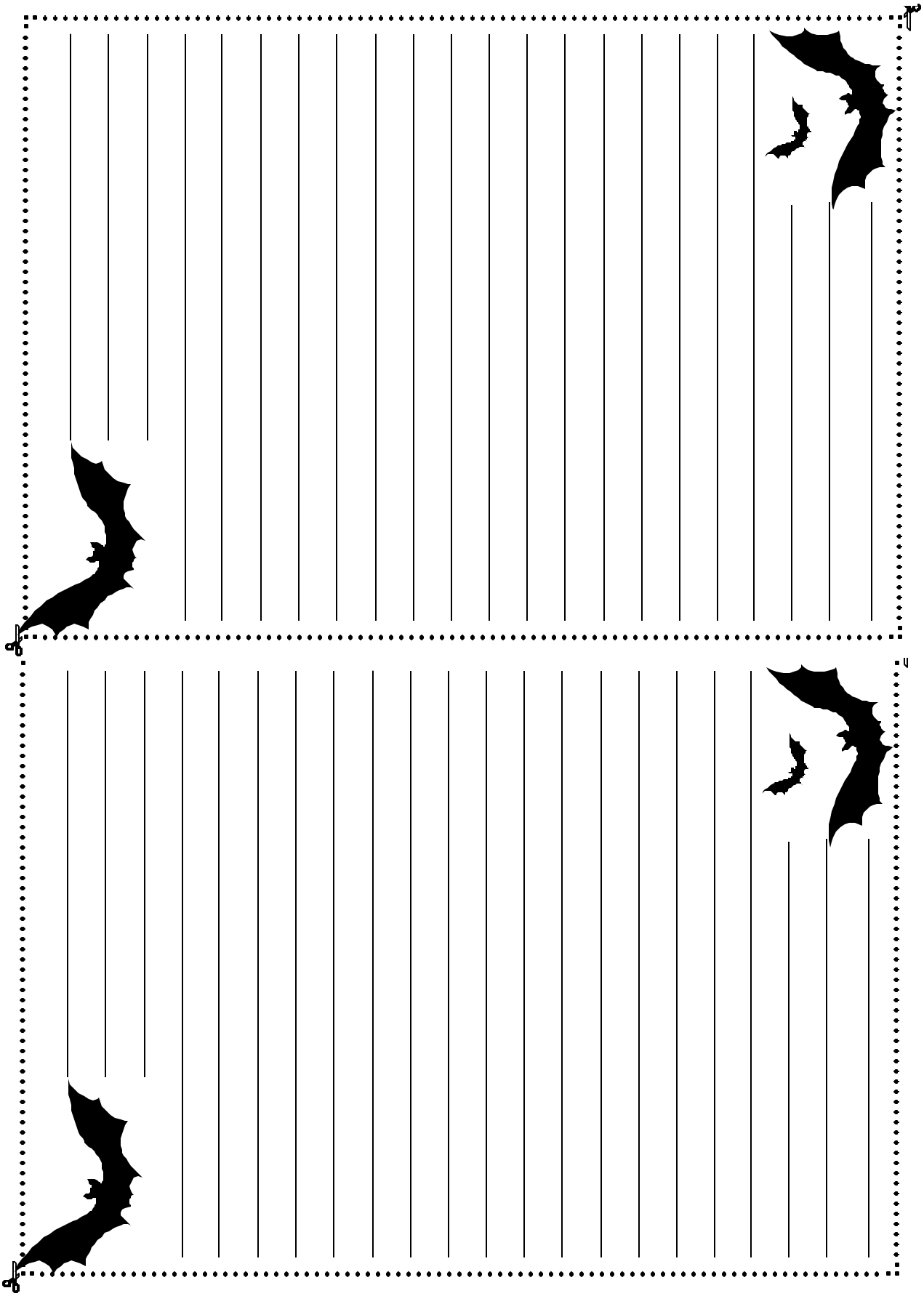
On a field trip to a cave and it's surrounding nature preserve, you and your friend ignore your chaperone and take a trail that's been closed. Suddenly the ground beneath your feet gives way and you fall into the earth.

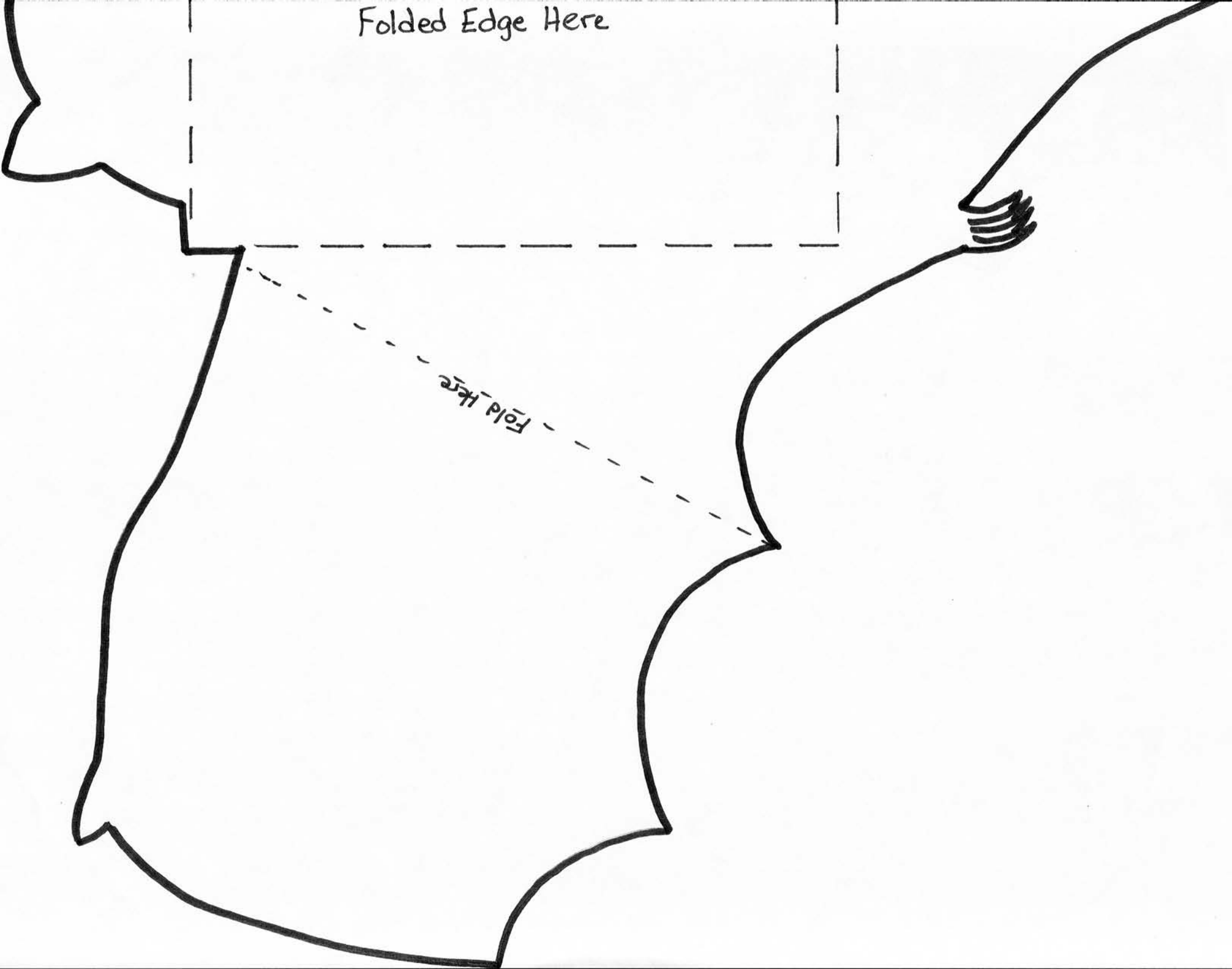
You awaken at dusk, stretch your wings, and flap them gently several times. All around you your aunts stir the air as they leave the roost. One more stretch, and you take to the air to join the hunt.

Everything is still and cool in the hibernaculum, and as you drift to sleep amongst your brothers and sisters you have the most amazing dream.

The girl who lives down the block wants to show you a really cool creature she found while exploring a cave on their summer vacation. You tell her she should not have taken it from it's home, but you can't resist your curiosity...



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20 Web of Decay

Cave Food Web Game

Materials: Game cards ● Simplified food webs (enlarged) ● Energy Tokens or string (Optional)

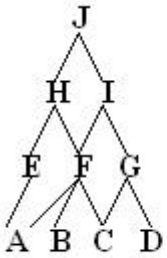
The flow of energy in cave ecosystems is very different from terrestrial ecosystems. However, a review of a "regular" ecosystem will help prepare students for the odd world beneath their feet. So it is recommended that you play the "Food Web Game" several times before moving on to the Cave version. Before you begin either game, discuss the roles that organisms play in their environment and how they all rely upon on another for survival. This includes everything from microscopic bacteria to the largest animal species in that environment.

You may want to review the following terms before you begin:

Decomposers—Derives its energy from eating dead matter and in the process breaks dead materials into "parts" (i.e. nutrients and minerals);
Producers—plants; rely on the sun for their energy (bring energy into the system)
Primary Consumers—Herbivores; rely on producers for their energy
Secondary Consumers—Carnivores; rely on primary consumers for their energy

Sample Web

(Energy flows from A,B,C,D toward J)



E eats A
F eats A, B, & C
G eats C & D

H eats E & F
I eats F & G

J eats H & I

Sample Terrestrial Scenario:
Invasive moth kills C
G eats D only – D #s go down
F eats A&B – they go down
E has more competition for A & less available – E #s go down

A food chain/web shows how each living plant and animal gets food. Some animals eat plants only (herbivores), some animals eat plants and animals (omnivores), and some animals eat only other animals (carnivores). A total food chain always starts with a plant and ends with an animal. Almost all animals are part of several food chains because they eat more than one type of plant and/or animal in order to survive. These interconnected food chains form a food web.

Basic Food Web Game

1. Divide students into uneven groups (3-4 groups depending on class size).
Group with largest number = plants
Next largest group = herbivores
Then = carnivores
Finally have 1 or 2 top carnivores

2. Arrange by trophic level i.e.:

Autotrophs	Heterotrophs		
Plants	Herbivores	Carnivores	Top Carnivore
1° producer	1° consumer	2° consumer	3° consumer

3. Have them choose their animals and figure out who eats whom.

4. Trace energy through ecosystem. (Poker chips, small pieces of paper, or some other token can be used to represent energy. If you use energy tokens, be sure to "lose" some at each exchange to represent heat loss. Alternatively, string or yarn can be stretched between students to show how each level gets energy from the preceding level.)

What would happen to the ecosystem if one of these levels were to be affected by adverse conditions (drought, pollution, habitat destruction, etc.)? Illustrate this by changing the ecosystem. Use some creativity to "kill" or reduce population of some creatures (or increase them), then track what happens.

Sample Scenarios

1. Reduce a producer's (plant) population via invasive species (e.g. Dutch elm disease), catastrophe (fire), extinction of animal partner (e.g. seed disperser or pollinator)
2. Reduce a 1° consumer (herbivore) via elimination of food source, or any of the aforementioned.
3. Reduce a 2° consumer (carnivore) via food chain amplification (e.g. DDT) or any of the aforementioned.

Cave Food Web Game

1. Pass out the Web of Decay cards. The basic set is designed for class size of 30 students. The expansion set can be used to increase class size. If there are less than 30 students then use cards A-D (or A-C) from the basic set. Be sure to make sure that there is more detritus (bat guano, leaf litter, and dead animals) than any other level. You may want to remind students that even though detritus is the base of food webs in caves where there is no light that the original source of energy was plant life outside of the cave. All energy floats in, blows in, or is carried in on the wings of bats (or by other animals).

3. Have the students find the other members of their trophic level. You should only have a small number of top carnivores relative to the other groups.
   Detritus
   Decomposers (Primary Consumer)
   Primary Carnivores (Secondary Consumer)
   Top Carnivores (Tertiary Consumer)

4. Figure out who eats whom or what. (Optional: Enlarge "Simplified Cave Food Web" sheet and challenge students to figure out where they belong.)

5. Trace energy through ecosystem. (Poker chips, small pieces of paper, or some other token can be used to represent energy. If you use energy tokens, be sure to "lose" some at each exchange to represent heat loss. Alternatively, string or yarn can be stretched between students to show how each level gets energy from the preceding level.)

6. What would happen to the ecosystem if one of these levels were to be affected by adverse conditions? Choose from any of the following scenarios or make up your own!

   Cave Ecosystem Scenarios

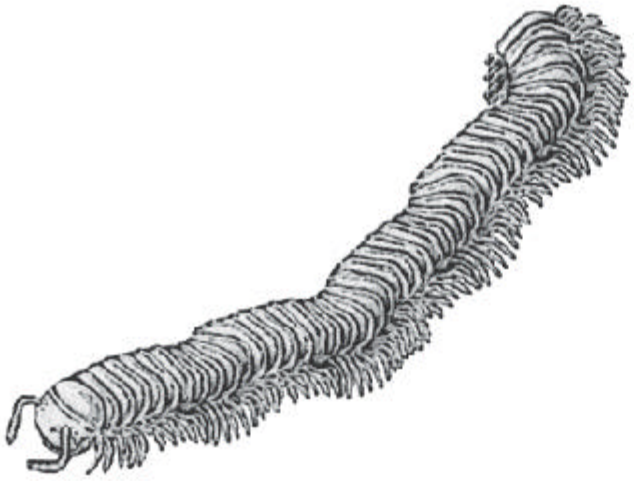
   1. Human disturbance raises the temperature of the cave during the winter.
   2. A new pesticide decimates a maternity roost.
   3. A sinkhole brings new light into a dark zone of the cave.
   4. Careless forestry practices reduce the population of Indiana bats.
   5. High winds blow large numbers of leaves into the cave in the fall.
   6. A flash flood scours the cave one evening, removing all the detritus but not harming the salamanders and bats that were out foraging.
   7. An invasive species of carnivorous fish (or spider) moves into the cave.

7. If time allows, pass out the cards from the "Enter into Twilight" edition of the food web game. Play as before. However, make sure that students notice the differences between cave food webs when light and plants are present. Specifically, that both plants and detritus are used as sources of energy in cave entries and the twilight zone. The communities are also made up of different species. Some animals can't tolerate the bright light and increased competition in these zones and are not present. However, several species that don't penetrate deep within the cave have been added to the food web. Use the "Enter into Twilight" simplified food web to help guide your students through the effect of sunlight (even meager sunlight) on cave ecosystems.

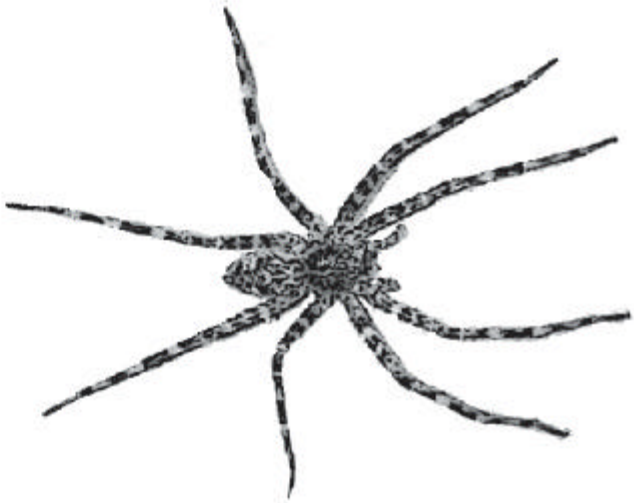
Summary Points

- The food supply for most animals can be traced back to plants. Therefore, without plants animal life would not exist. Even the energy for cave ecosystems are based on plants that live in the area around the cave.
- Insects and various other organisms depend on dead plant and animal material for food.
- That some source of energy (i.e. sunlight or food) is needed for all organisms to stay alive and grow.
- Nutrients cycle through systems and may be reused, but energy flows and is lost as heat.
- There is no light (and thus no source of energy) deep in the cave, so all the energy that enters a cave ecosystem must come from outside the cave (must either float in, blow in or be carried in by an animal).
- Caves with large bat populations have the most diverse communities.
- Cave communities are larger and more complex near openings or other sources of light.

Cave Ecosystem Game Cards - Basic Card Set A (Copy on cardstock and cut out.)

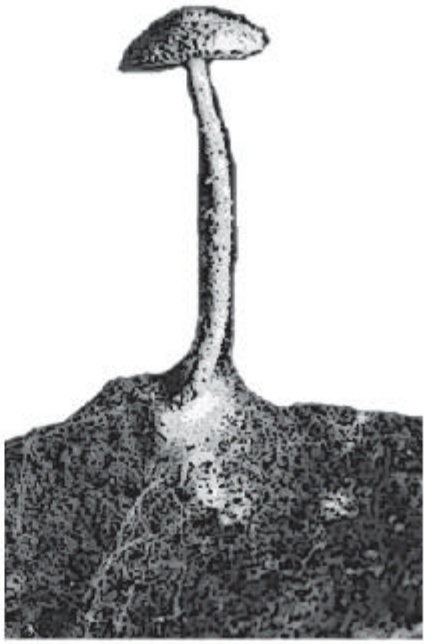


Millipede



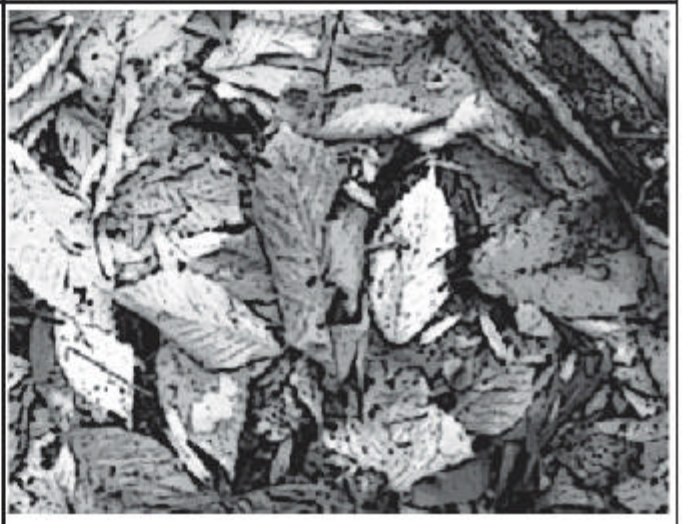
Fishing Spider

Mold



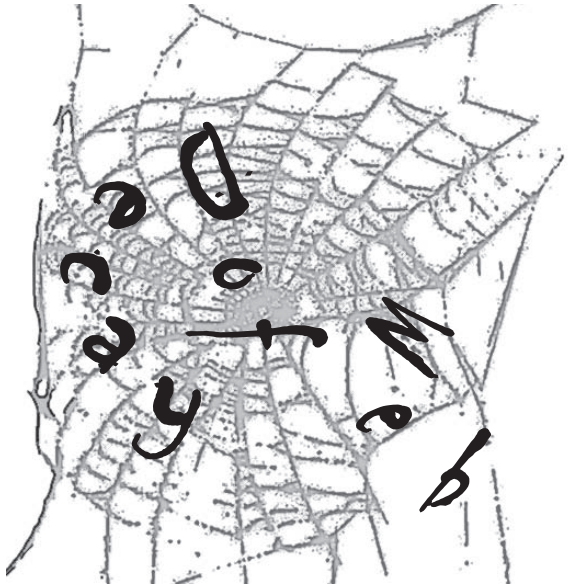
Fungi

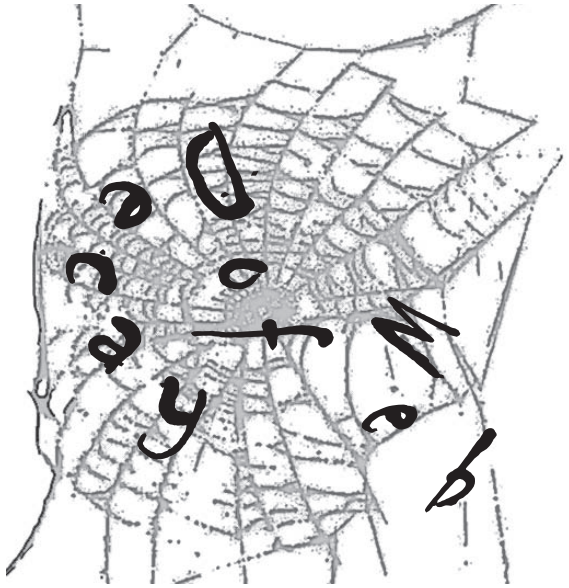
Bat Guano

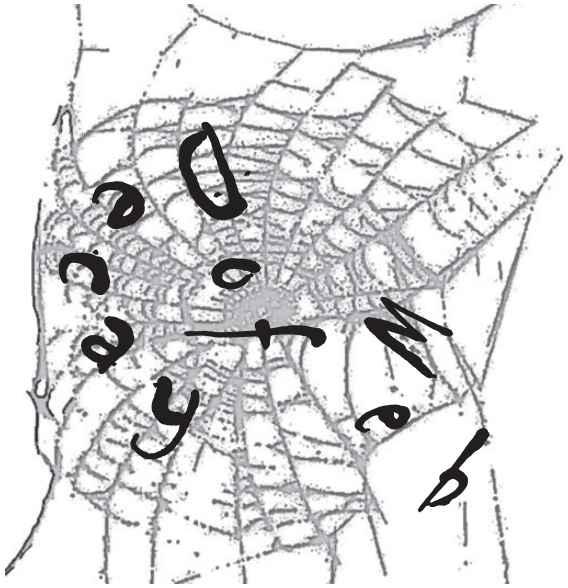


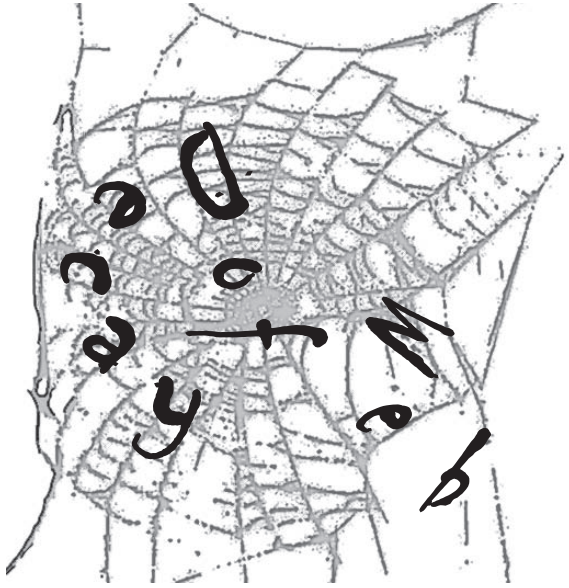
Leaf Litter

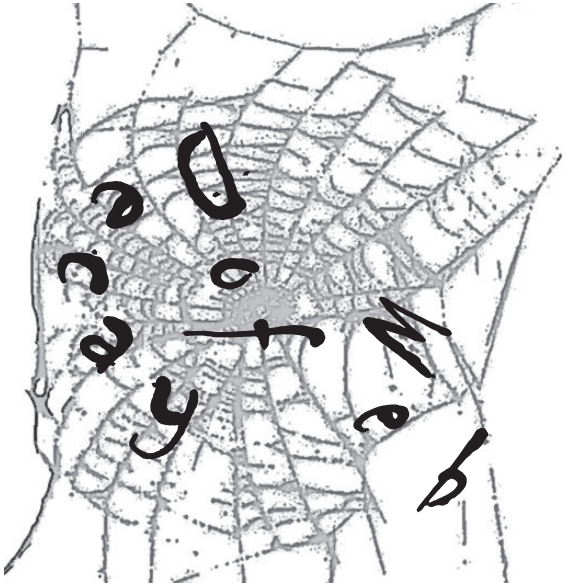
Cave Ecosystem Game Cards - Back of Cards (Copy on cardstock and cut out.)

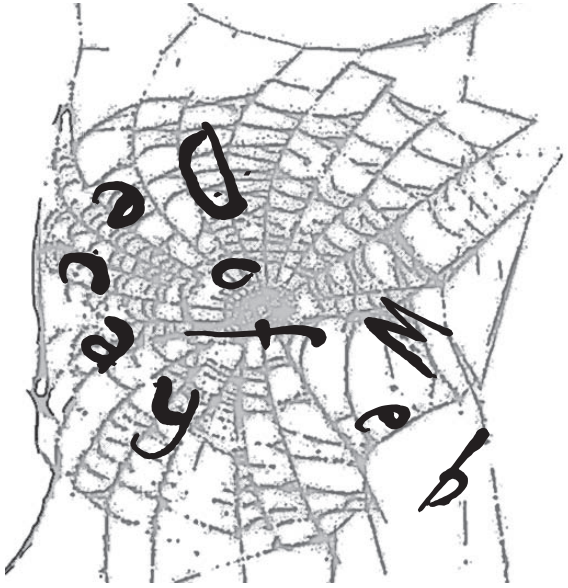




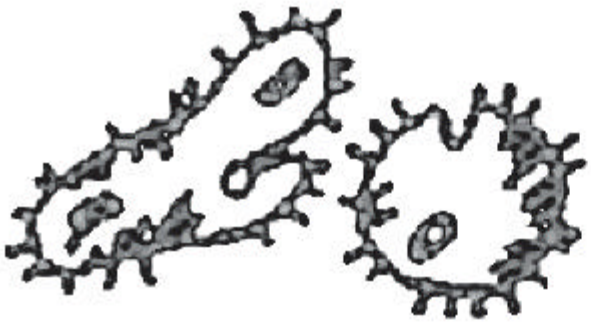




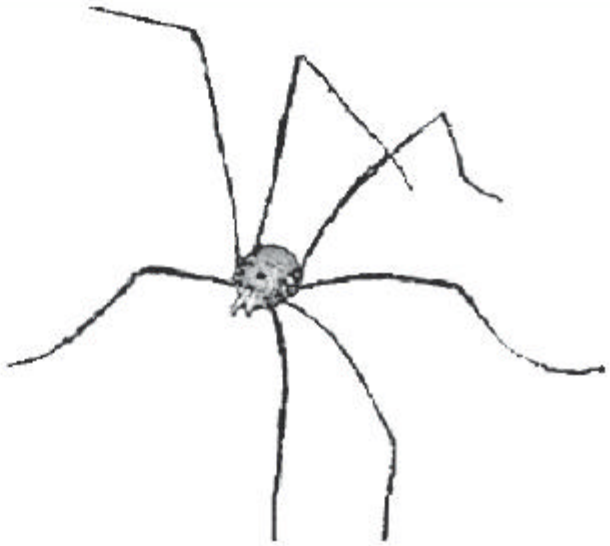




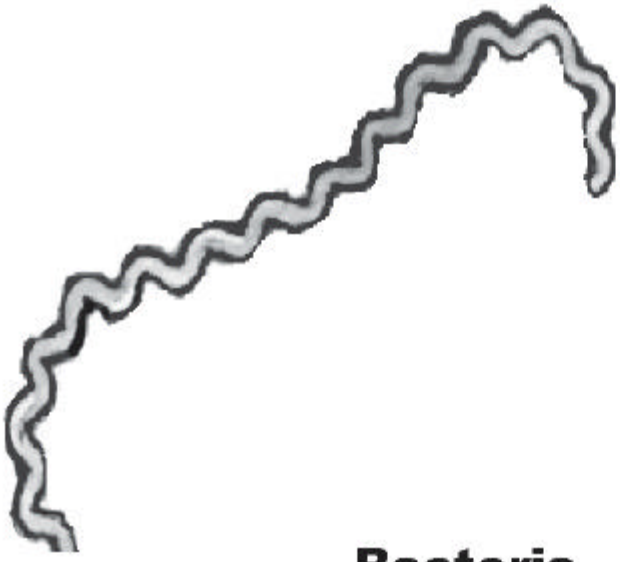
Cave Ecosystem Game Cards - Basic Card Set B (Copy on cardstock and cut out.)



Single-cell Organisms



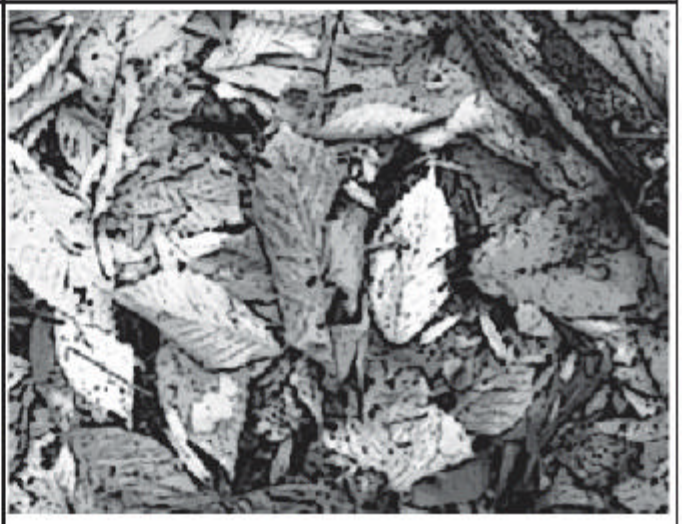
Harvestman
(Daddy Longlegs)



Bacteria

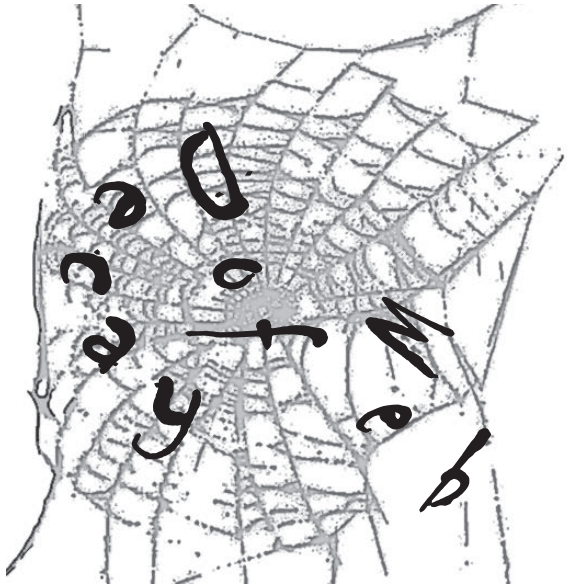
Dead Animals

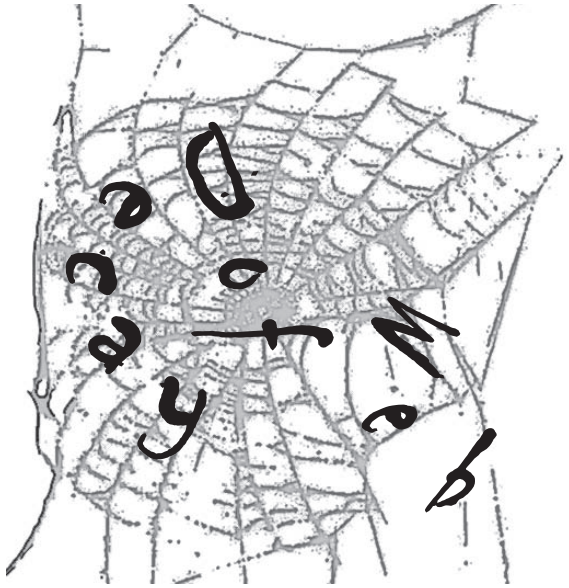
Bat Guano

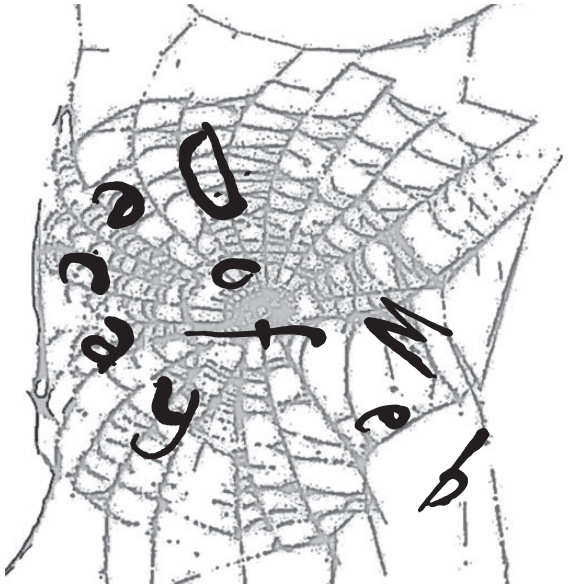


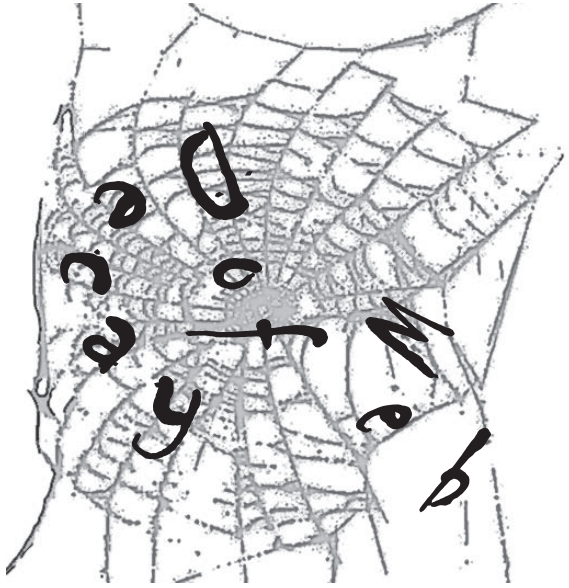
Leaf Litter

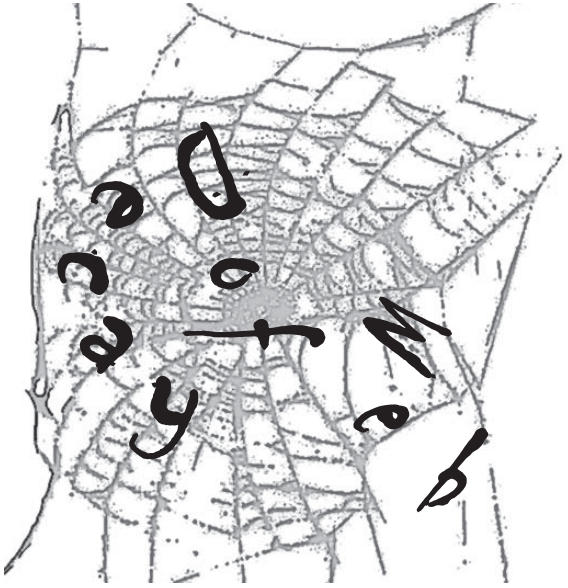
Cave Ecosystem Game Cards - Back of Cards (Copy on cardstock and cut out.)

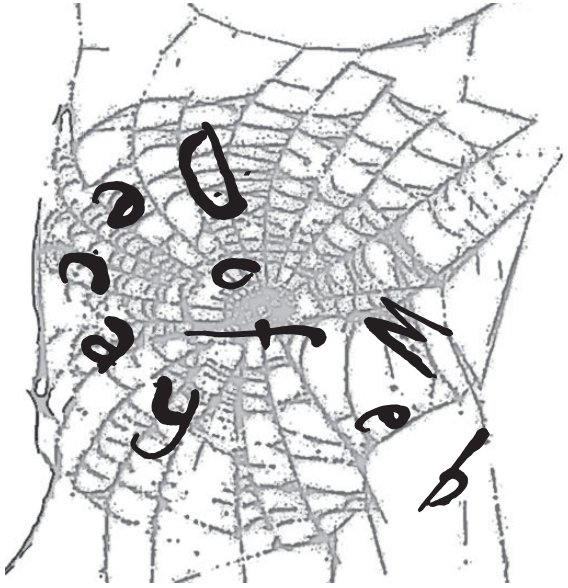




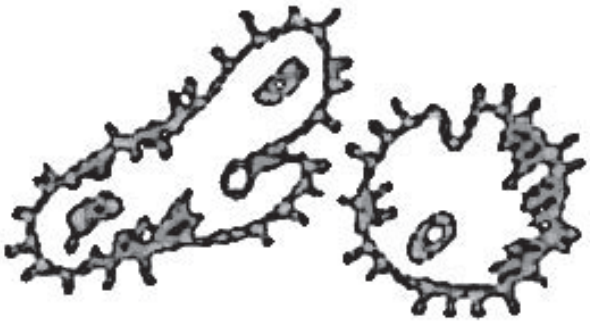






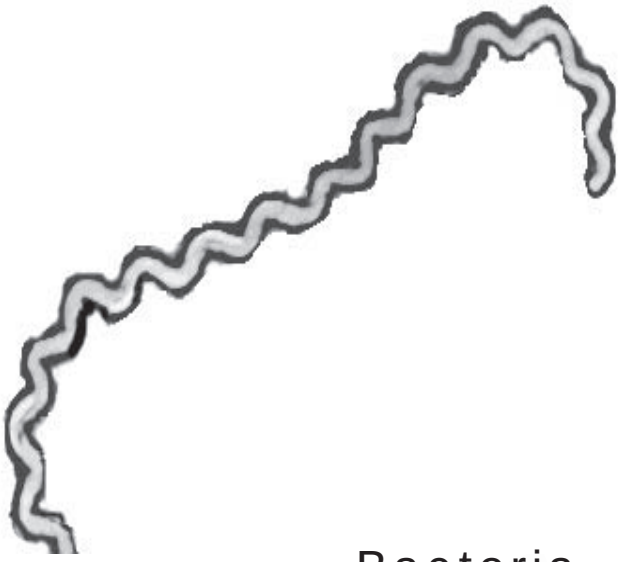


Cave Ecosystem Game Cards - Basic Card Set C (Copy on cardstock and cut out.)



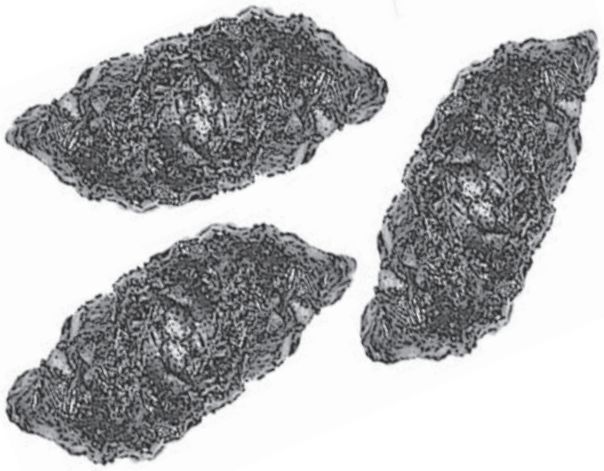
Single-cell Organisms

Cave Salamander

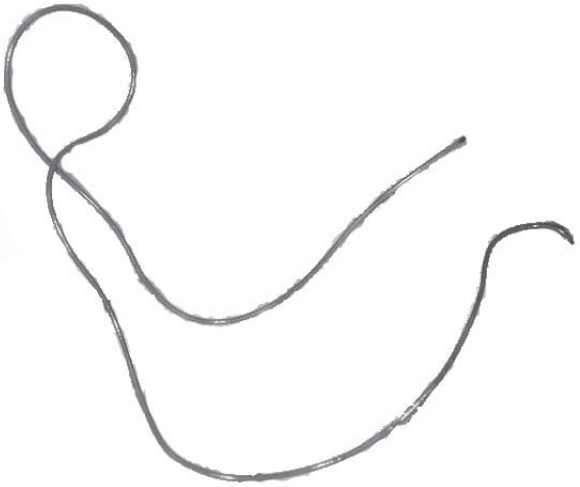


Bacteria

Dead Animals

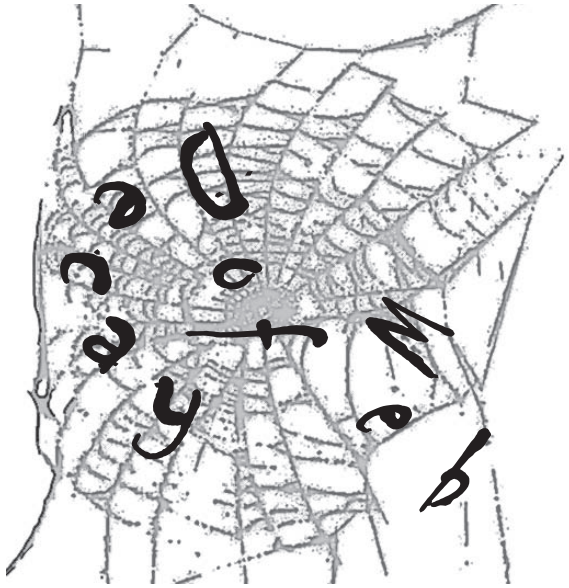


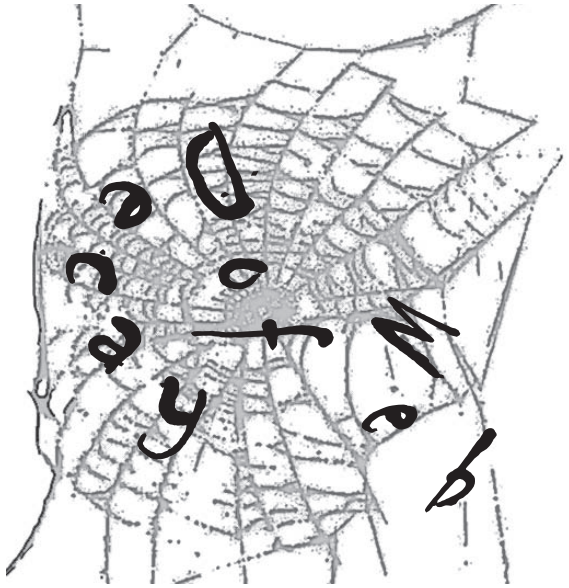
Bat Guano

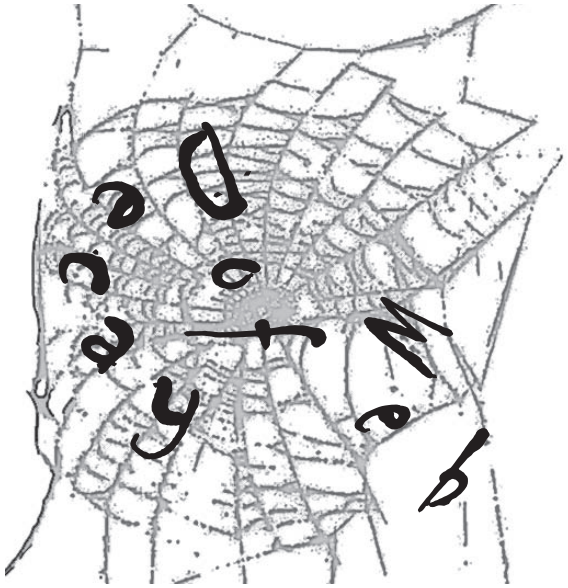


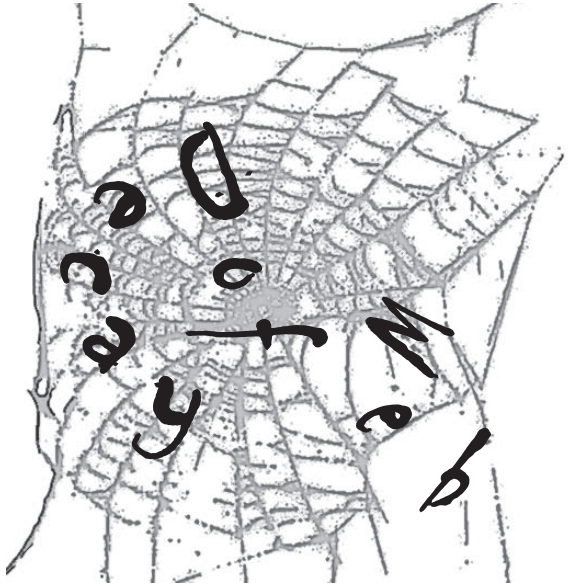
Gordian Worm

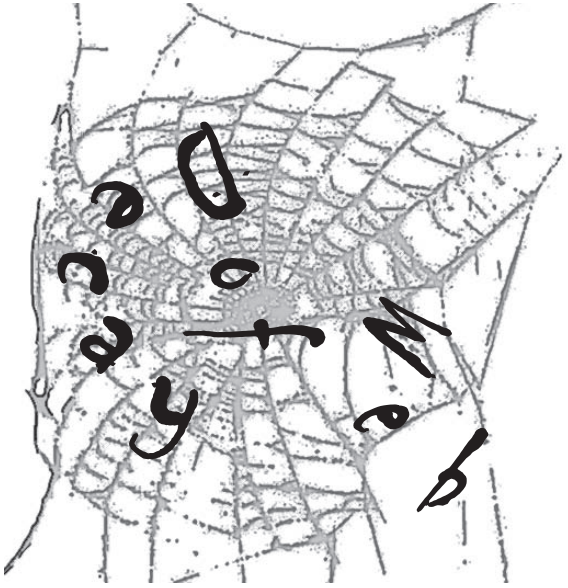
Cave Ecosystem Game Cards - Back of Cards (Copy on cardstock and cut out.)

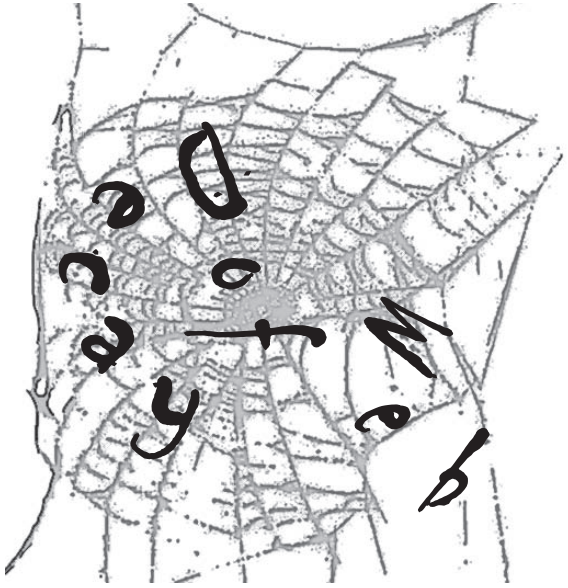




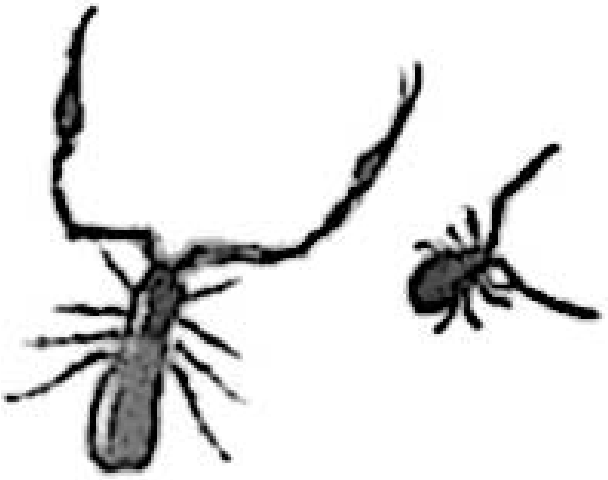




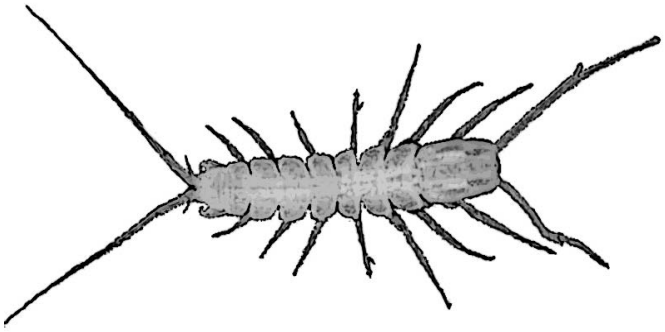




Cave Ecosystem Game Cards - Basic Card Set D (Copy on cardstock and cut out.)

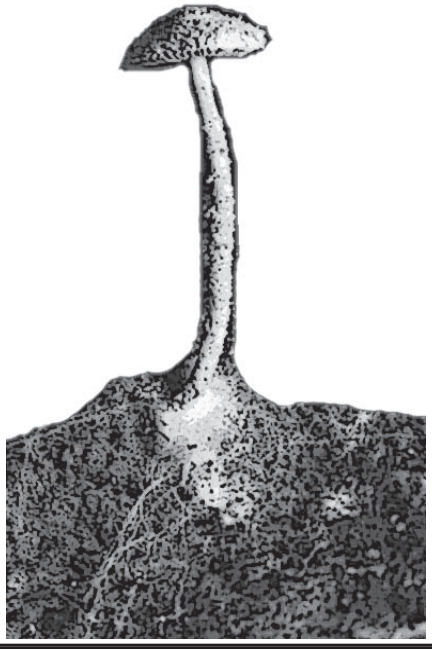


Pseudoscorpion

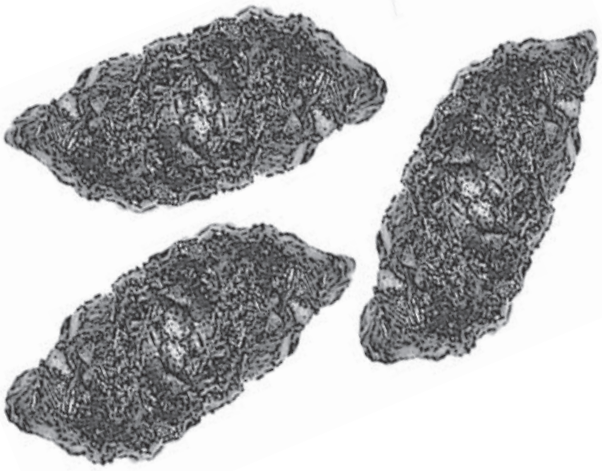


Aquatic Isopod

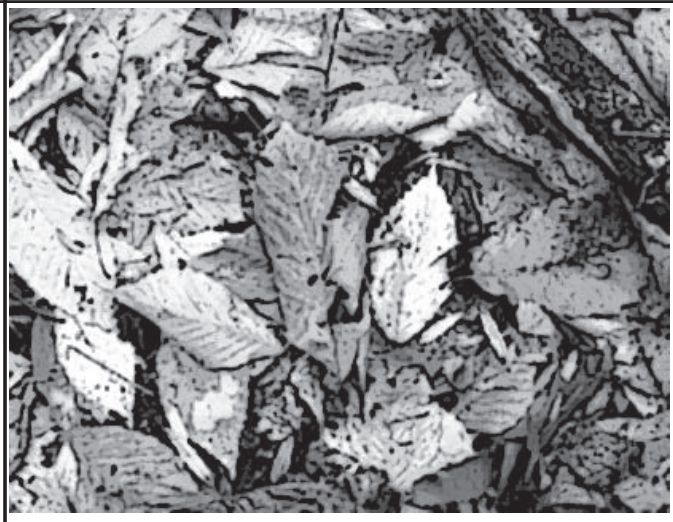
Mold



Fungi

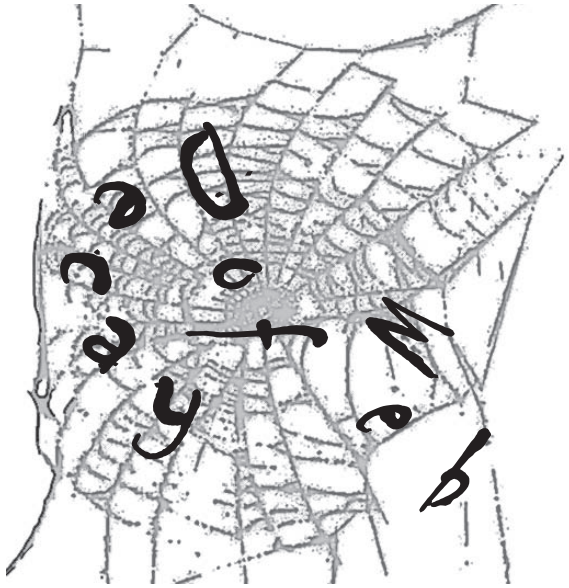


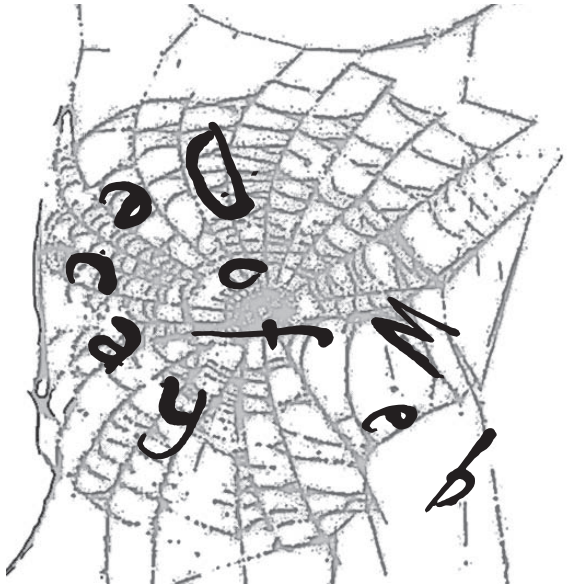
Bat Guano

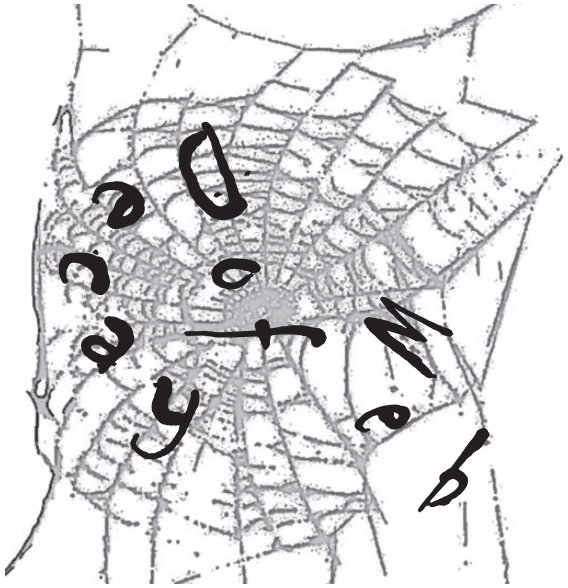


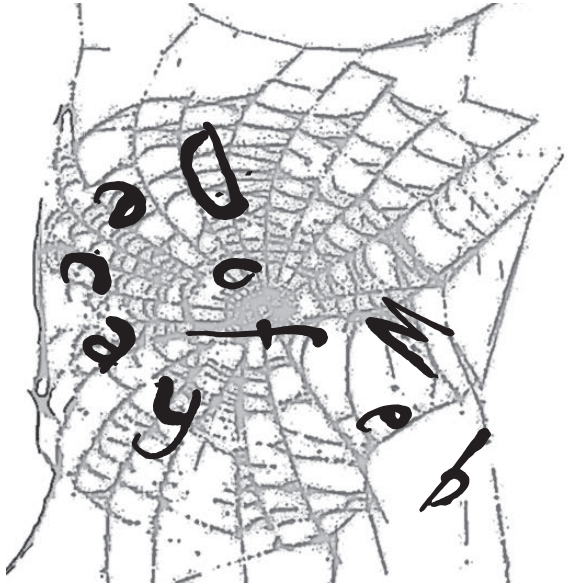
Leaf Litter

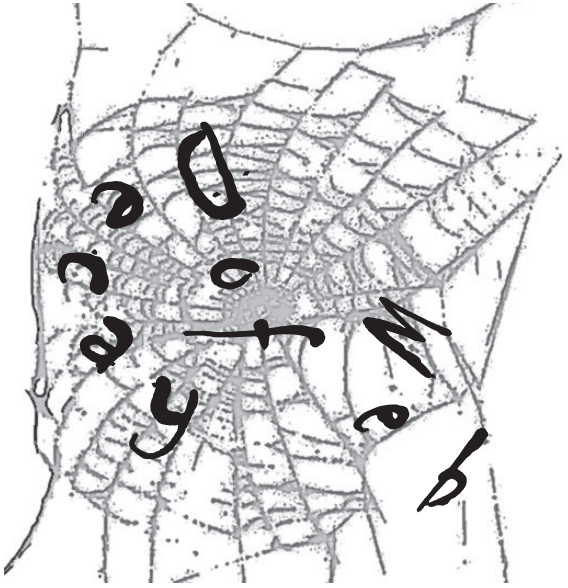
Cave Ecosystem Game Cards - Back of Cards (Copy on cardstock and cut out.)

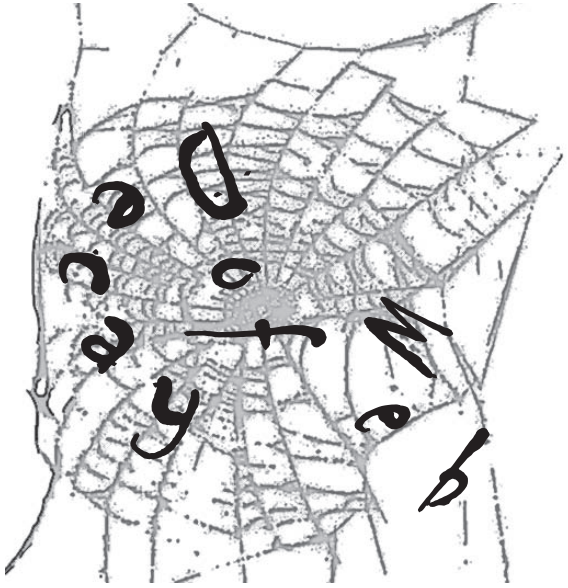




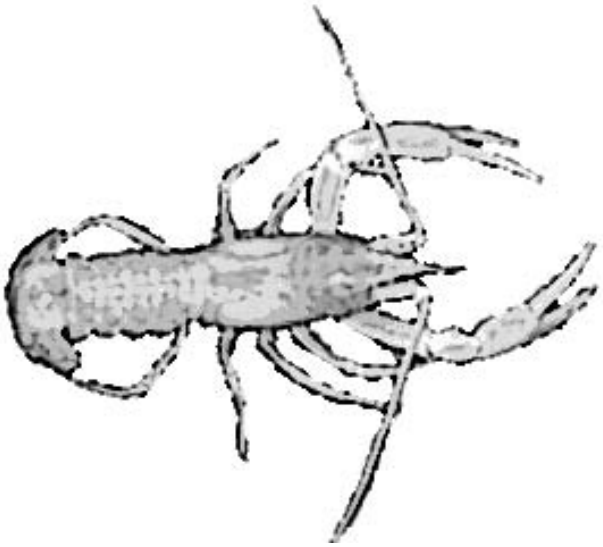






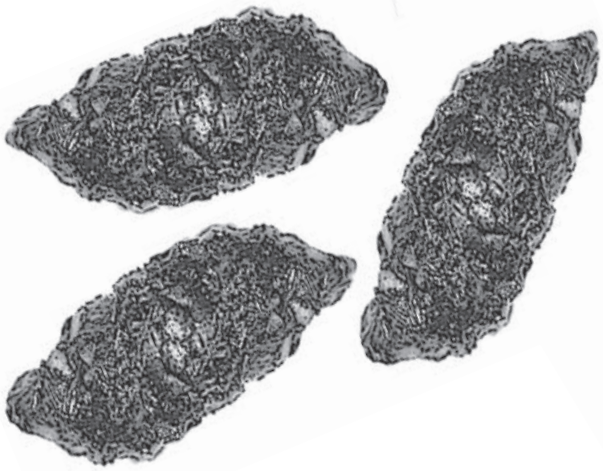


Cave Ecosystem Game Cards - Basic Card Set E (Copy on cardstock and cut out.)

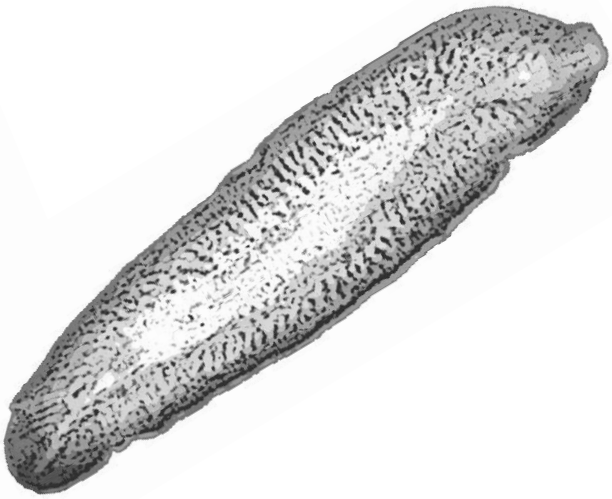


Cave Crayfish

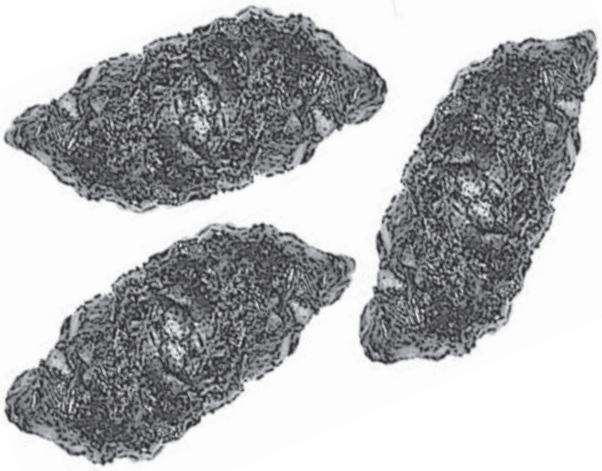
Rove Beetle



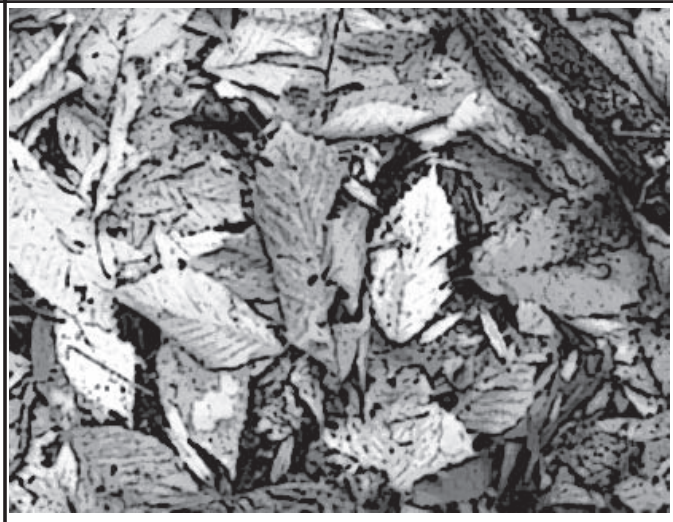
Bat Guano



Planaria

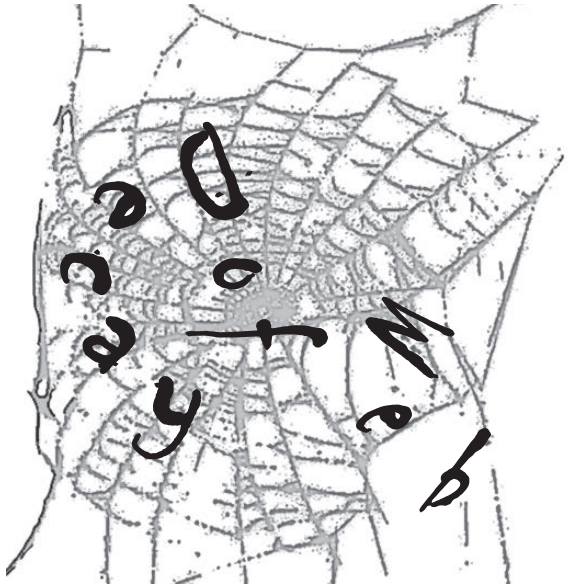


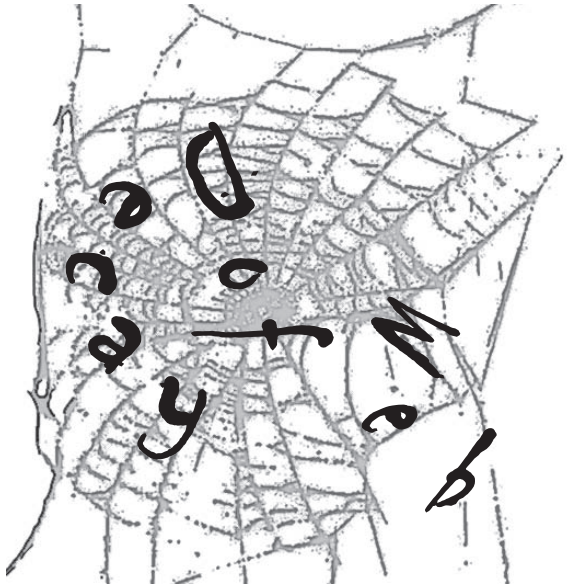
Bat Guano

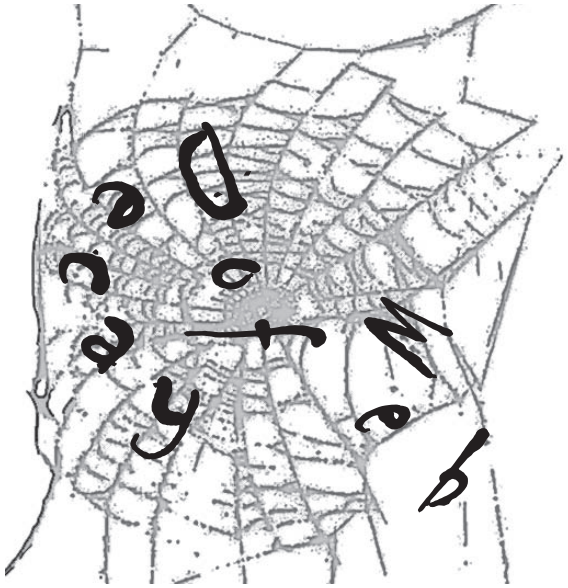


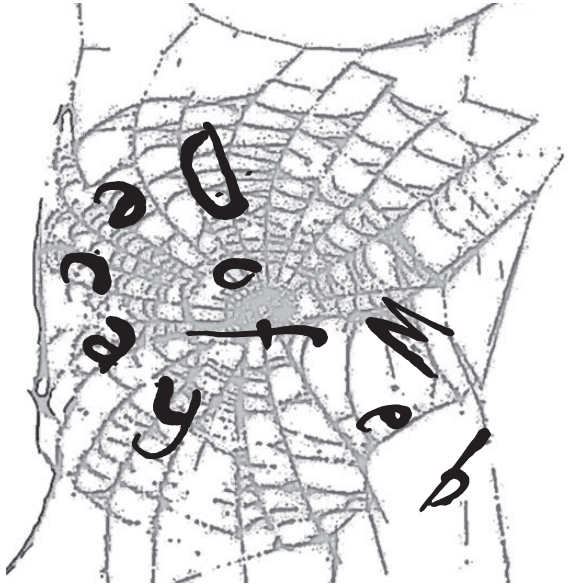
Leaf Litter

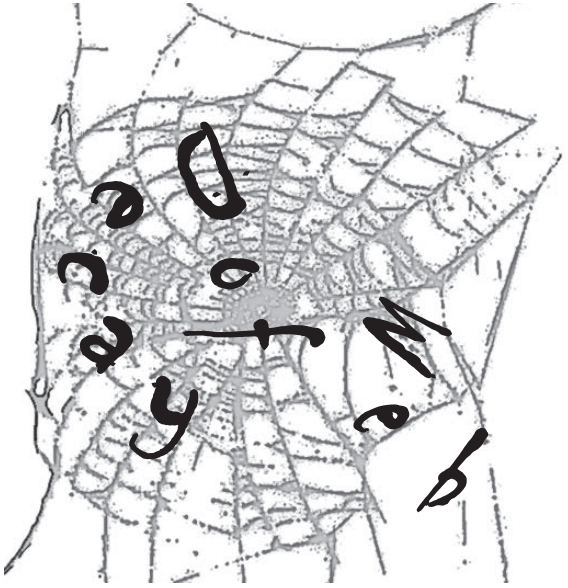
Cave Ecosystem Game Cards - Back of Cards (Copy on cardstock and cut out.)

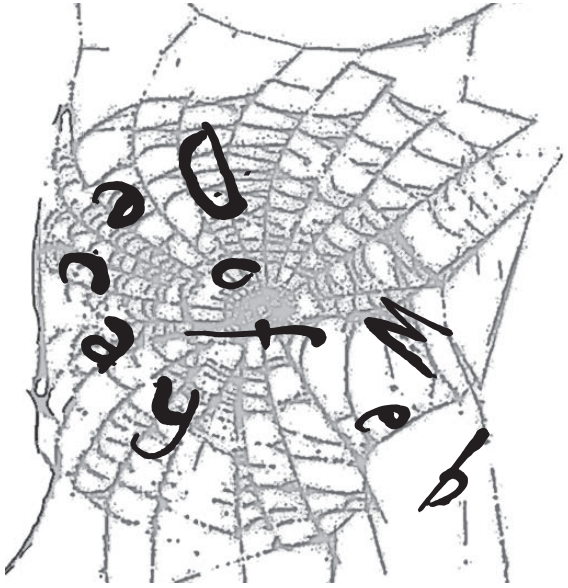




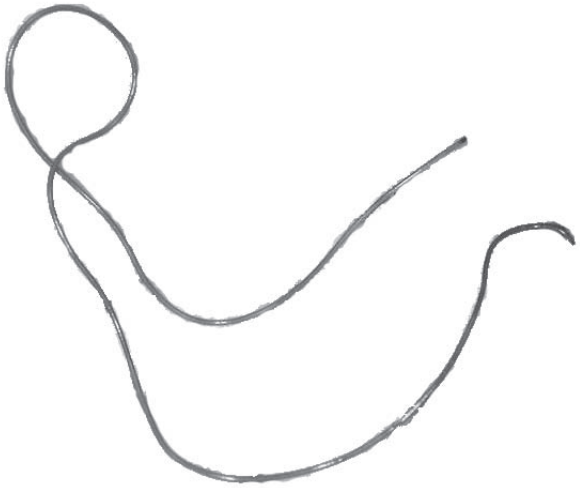






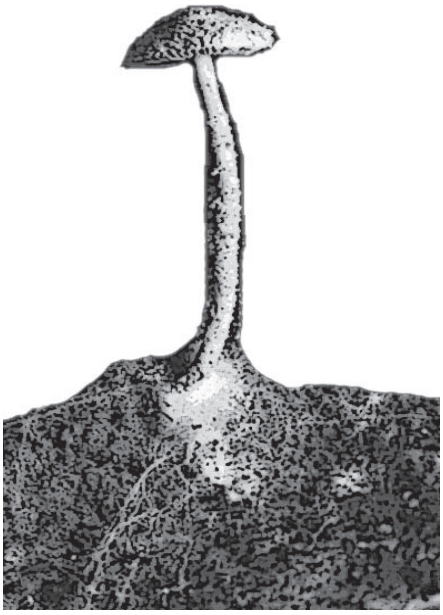


Cave Ecosystem Game Cards - Basic Card Set Expansion (Copy on cardstock and cut out.)



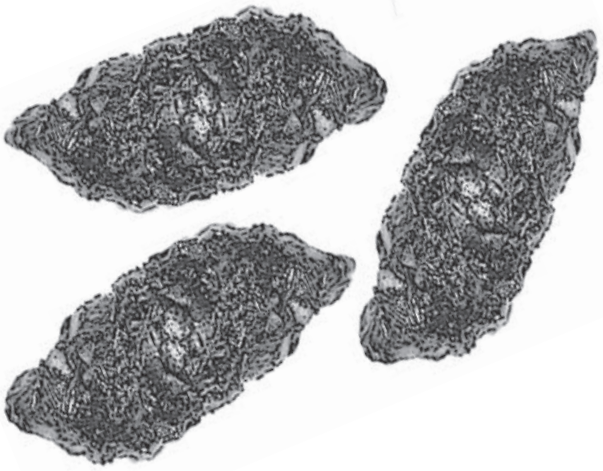
Gordian Worm

Harvestman
(Daddy Longlegs)

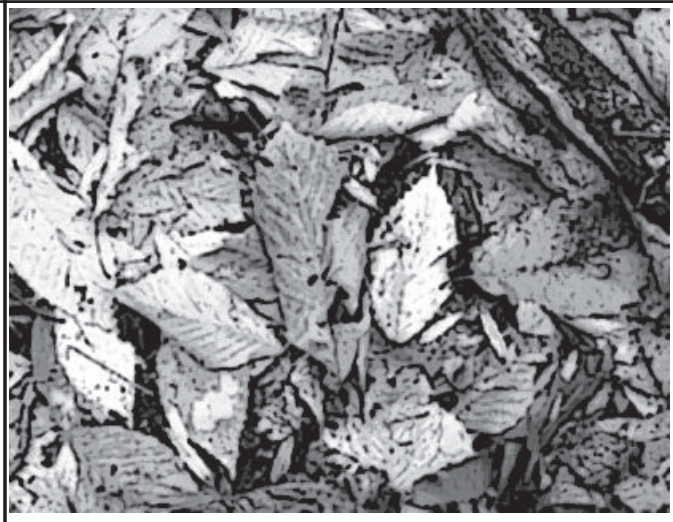


Fungi

Dead Animals

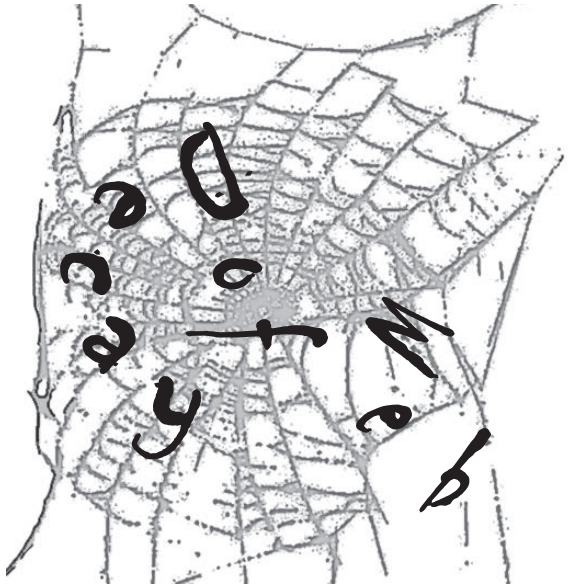


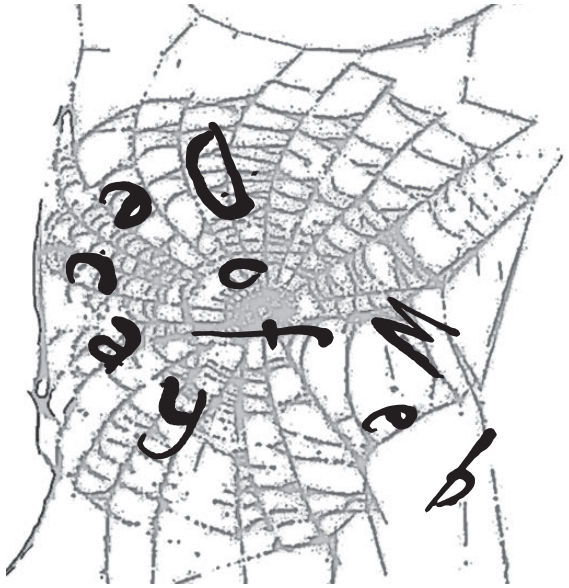
Bat Guano

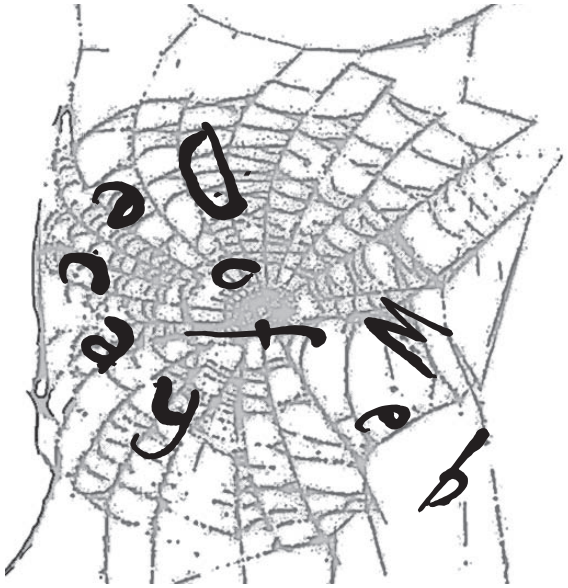


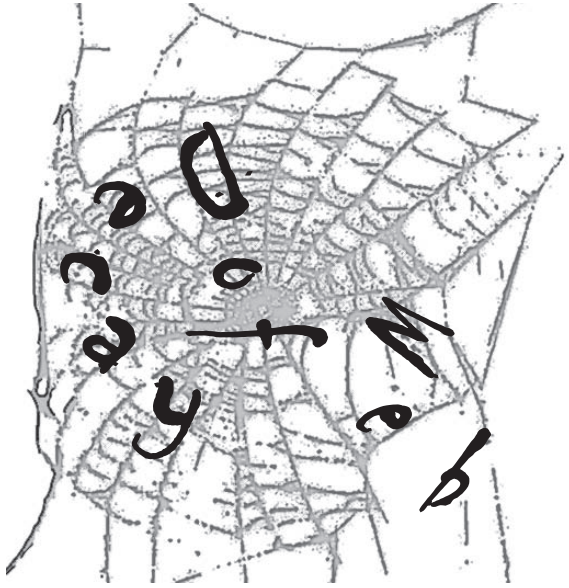
Leaf Litter

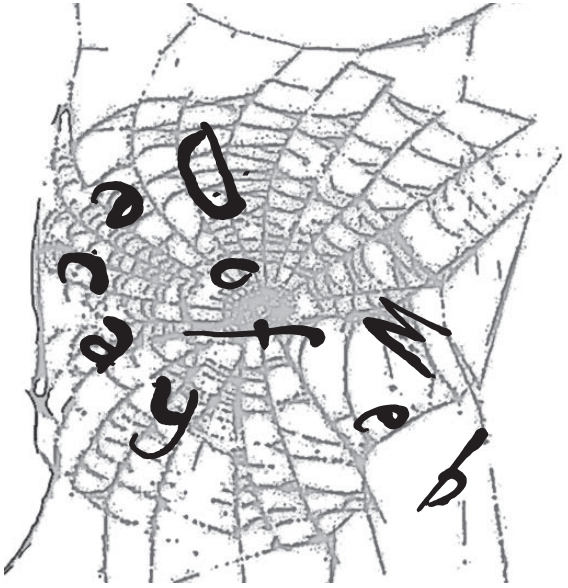
Cave Ecosystem Game Cards - Back of Cards (Copy on cardstock and cut out.)

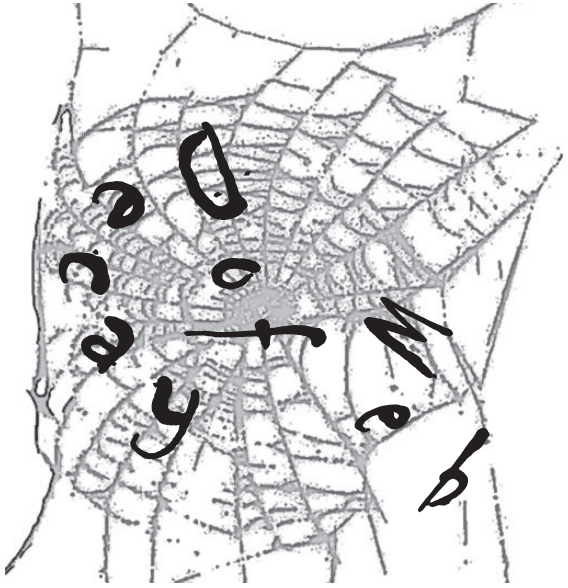




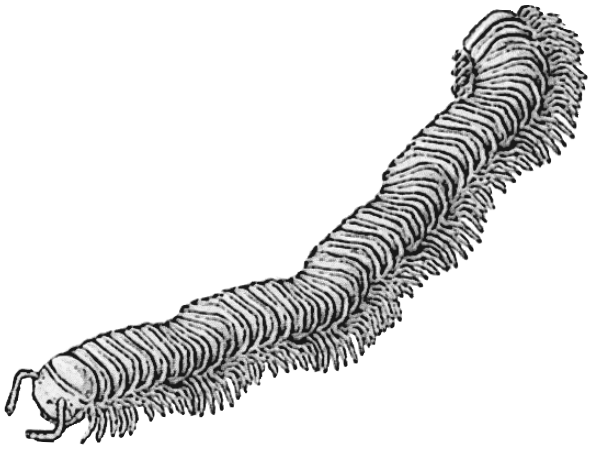




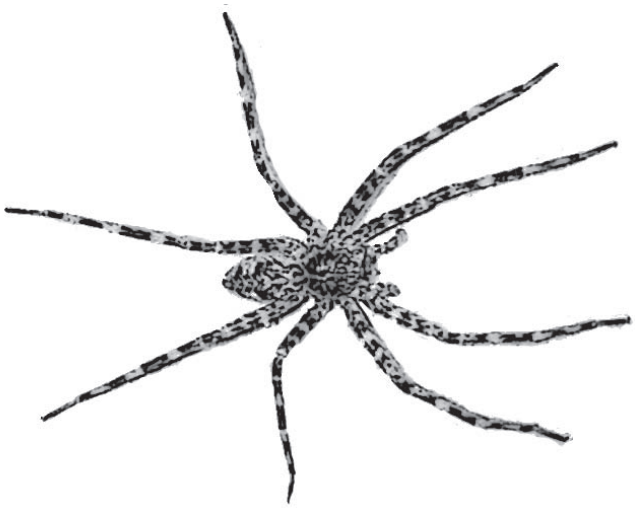




Cave Ecosystem Game Cards - Enter Into Twilight Card Set A (Copy on cardstock and cut out.)

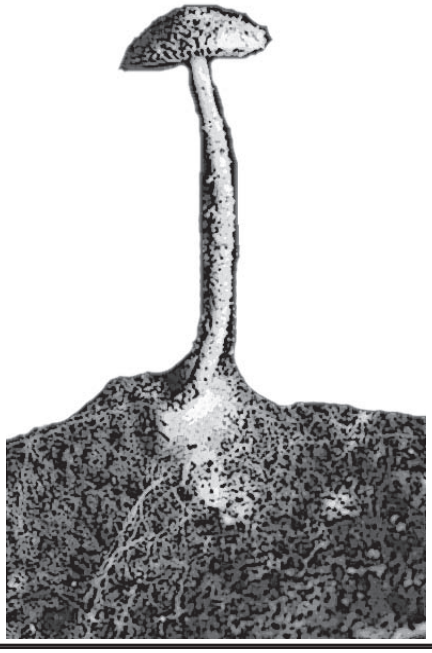


Millipede

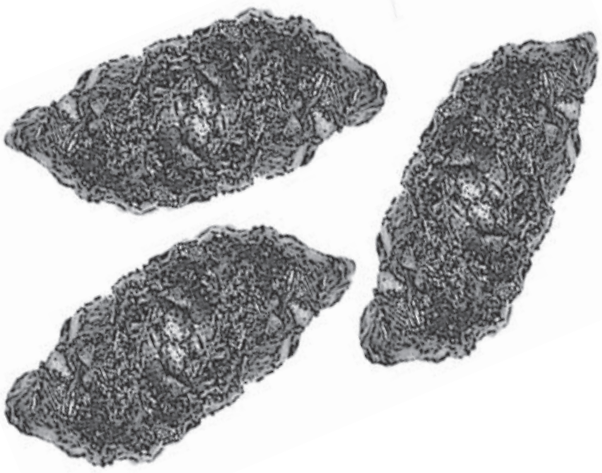


Fishing Spider

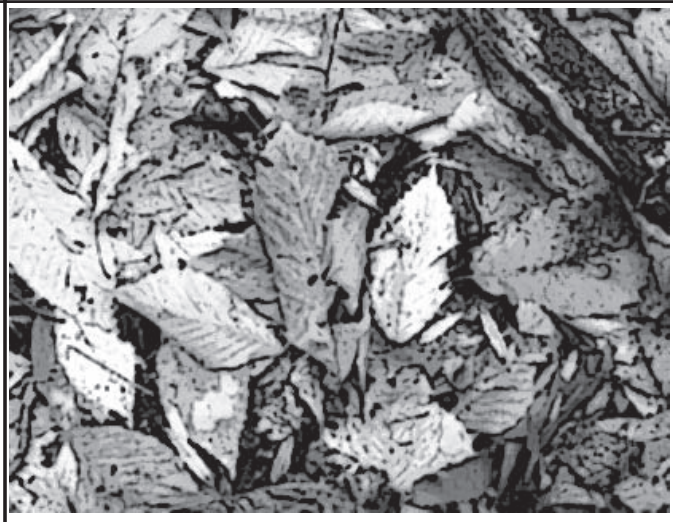
Mold



Fungi



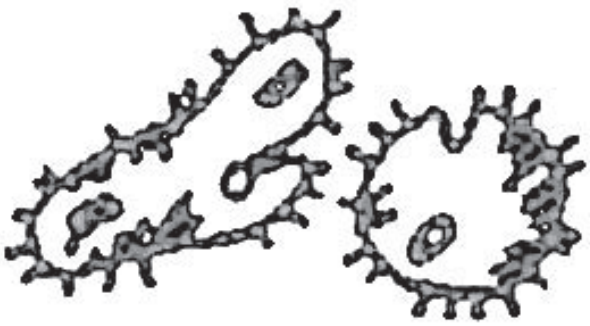
Bat Guano



Leaf Litter

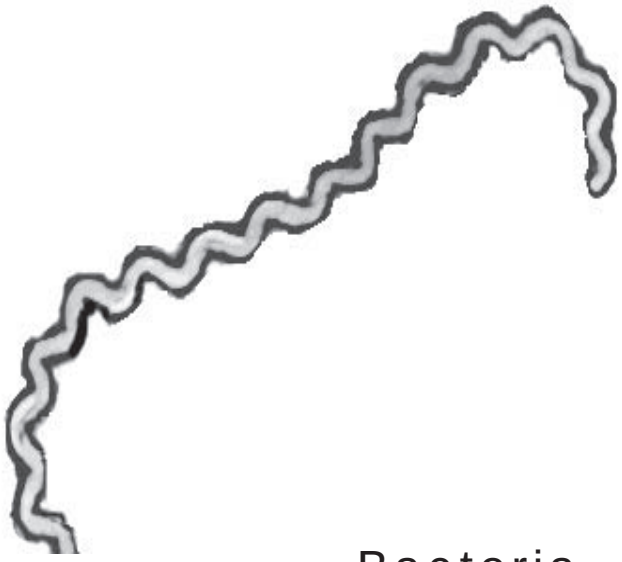
Cave Ecosystem Game Cards - Back of Cards (Copy on cardstock and cut out.)

Cave Ecosystem Game Cards - Enter Into Twilight Card Set B (Copy on cardstock and cut out.)



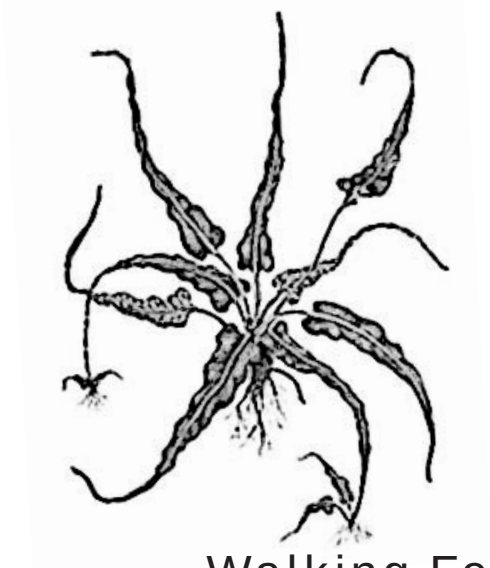
Single-cell Organisms

Harvestment
(Daddy Longlegs)

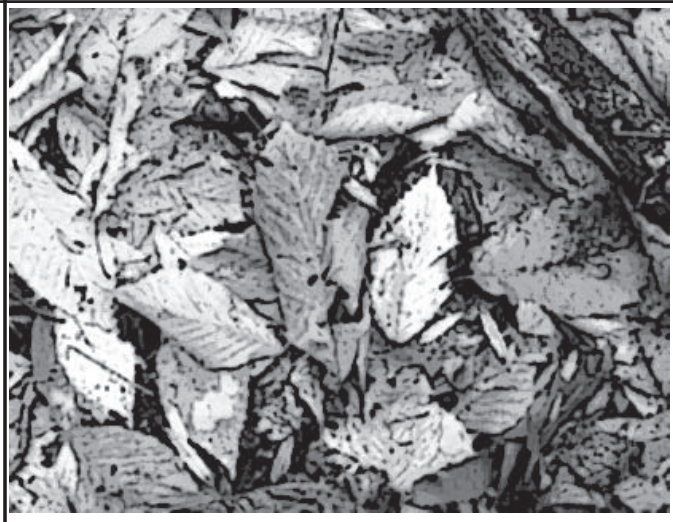


Bacteria

Dead Animals



Walking Fern



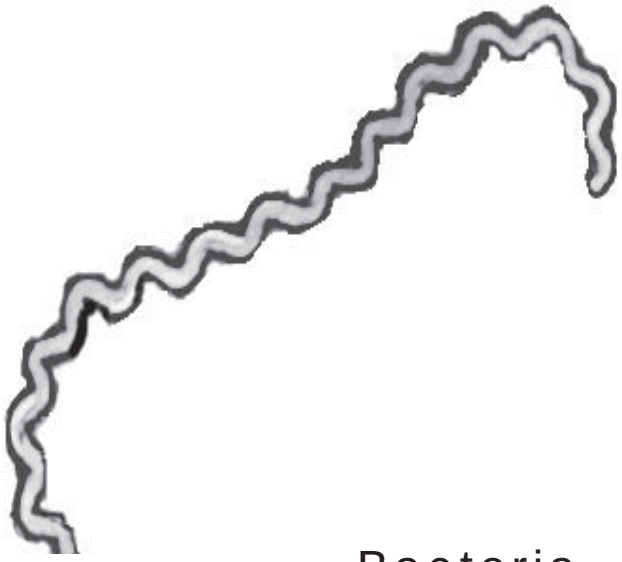
Leaf Litter

Cave Ecosystem Game Cards - Back of Cards (Copy on cardstock and cut out.)

Cave Ecosystem Game Cards - Enter into Twilight Card Set C (Copy on cardstock and cut out.)

Algae

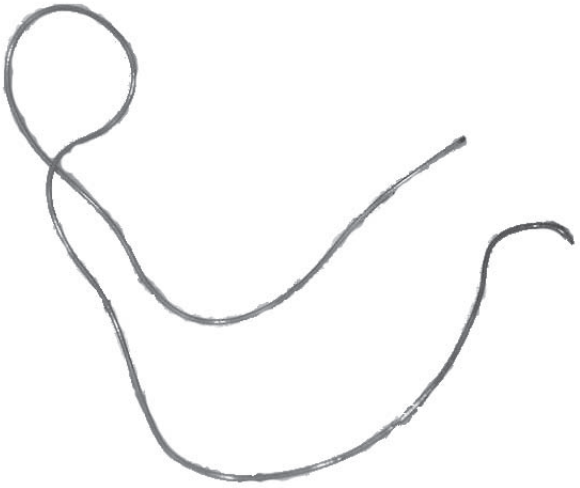
Cave Salamander



Bacteria

Dead Animals

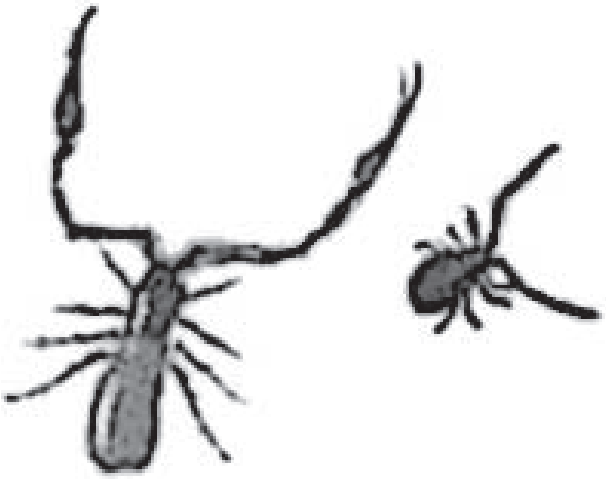
Algae



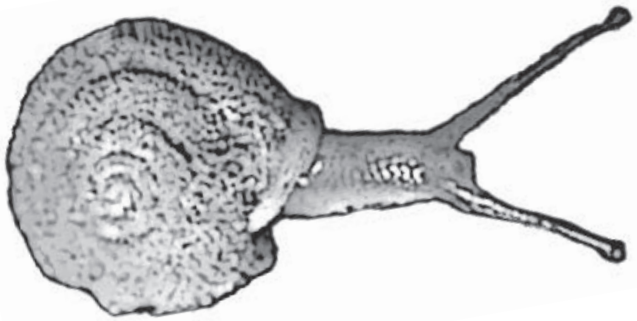
Gordian Worm

Cave Ecosystem Game Cards - Back of Cards (Copy on cardstock and cut out.)

Cave Ecosystem Game Cards - Enter Into Twilight Card Set D (Copy on cardstock and cut out.)

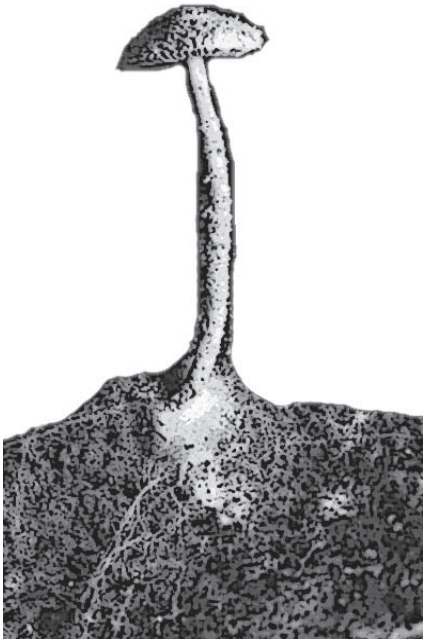


Pseudoscorpion

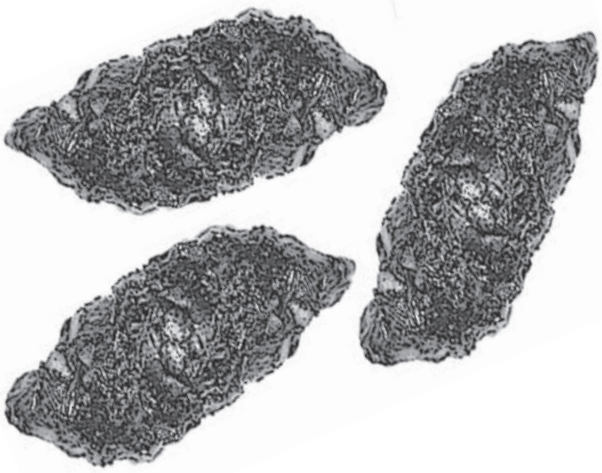


Snail

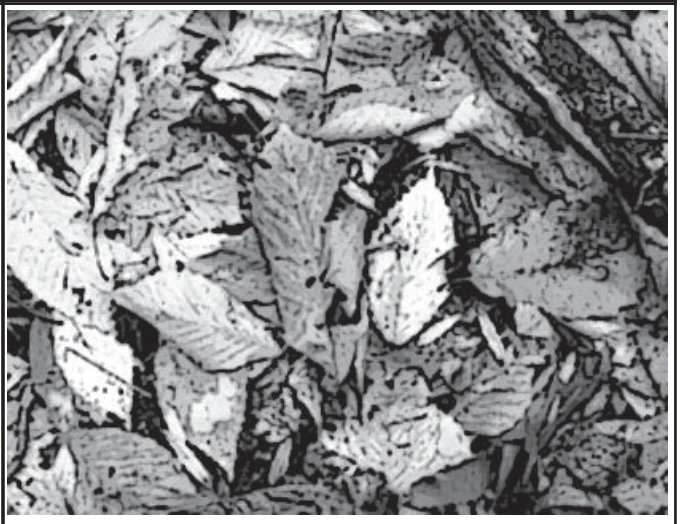
Mold



Fungi



Bat Guano



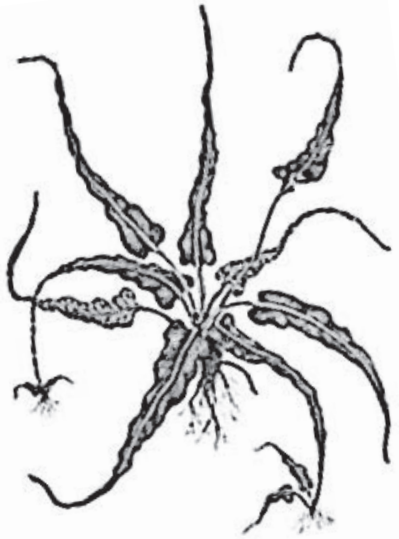
Leaf Litter

Cave Ecosystem Game Cards - Back of Cards (Copy on cardstock and cut out.)

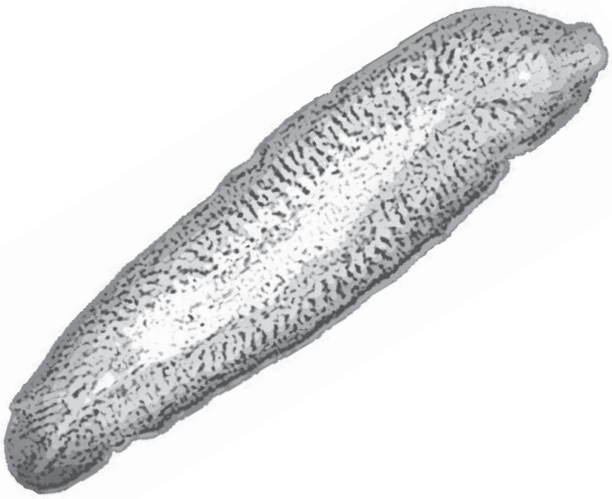
Cave Ecosystem Game Cards - Enter Into Twilight Card Set E (Copy on cardstock and cut out.)

Pickerel Frog

Rove Beetle



Walking Fern



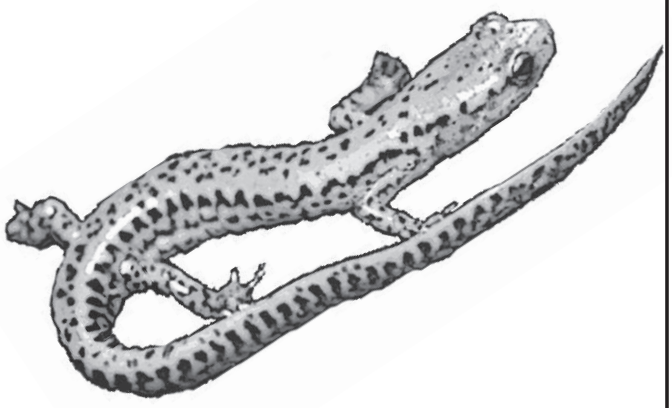
Planaria

Algae

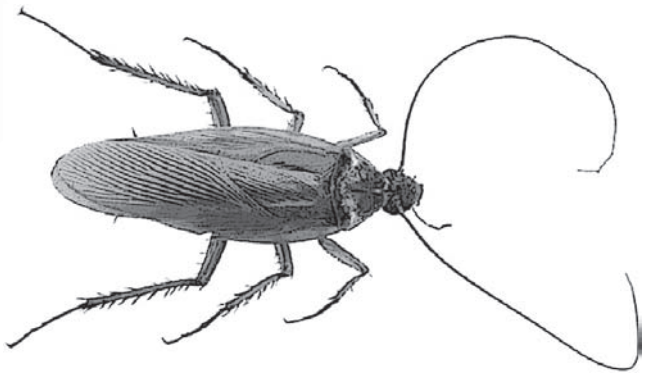
Ground Beetle

Cave Ecosystem Game Cards - Back of Cards (Copy on cardstock and cut out.)

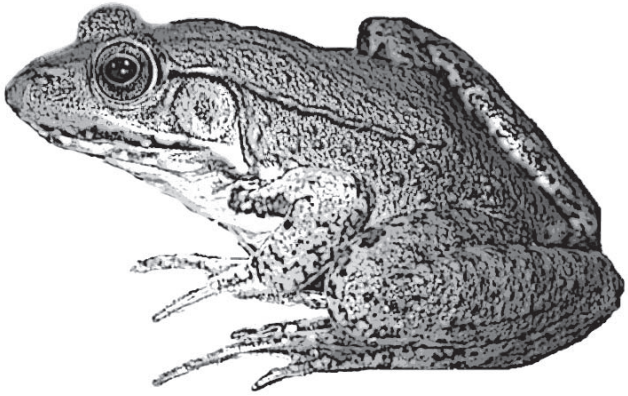
Cave Ecosystem Game Cards - Enter into Twililght Card Set Expansion (Copy on cardstock and cut out.)



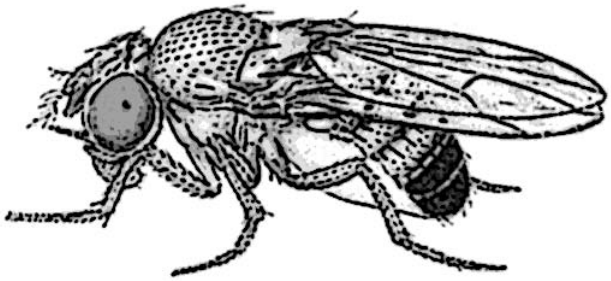
Long-tailed Salamander



Cockroach



Green Frog



Fly

Algae

Walking Fern

Cave Ecosystem Game Cards - Back of Cards (Copy on cardstock and cut out.)

Resources

Books

Appelt, K. *Bats Jamboree* (1996)
Bat Conservation International. *Educators Activity Book: About Bats* (1991)
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Halton, C. *Those Amazing Bats* (1991)
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Horowitz, R. *Bat Time* (1991)
Markle, S. *Outside and Inside Bats* (1997)
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Tuttle, M. *America's Neighborhood Bats* (2005)
Whitaker, J.; Brack, V. Jr.; Sparks, D.; Cope, J., Johnson, S. *Bats of Indiana* (2007)
Wood, L.; Rink, D. *Zoobooks: Bats* (2001)

Videos

Bat Conservation International. *The Secret World of Bats*. (1992)
Calestreme, N. *Merlin Tuttle: Guardian Angel of Bats*. Bat Conservation International
Kowalchuk, W.R. *Stellaluna*. MGM (2004)

Websites

www.batcon.org **Bat Conservation International**
www.boydencavern.com/classroom.htm **Boyden Cavern website**
www.cavebiota.com **Cave Biota, an Evolving Webumentary**
igs.indiana.edu/geology/index.cfm **Indiana Geological Survey**
www.caves.org/conservancy/ikc/ **Indiana Karst Conservancy**
www.caves.org **National Speleological Society**
www.batconservation.org **Organization for Bat Conservation**
www.goodearthgraphics.com/virtcave/ **"The Virtual Cave"**

Glossary

Term	Pronunciation	Definition
Adapt	uh-DAPT	To change to meet new or special needs; a species alters or adjusts itself to better survive in its environment
Adaptation	ah-dapt-TAY-shun	An inherited change by which a species or individual improves its condition in relation to its environment
Aerial insectivore	AIR-ee-al in-SECT-tih-vore	Any animal that chases or catches insect prey in flight (see also "foliage gleaner")
Aerodynamic	air-oh-dye-NAM-ick	Having a body shape designed for flying
Agave	ah-GAH-vay	A low-growing tropical American plant, such as the century plant, related to the lily and having fleshy leaves and a tall stalk of flowers; some species are used for their valuable fibers (for example, sisal) or for their fermented pulp which is used to make tequila liquor
Ambient	AM-bee-ent	surrounding; ambient temperature is recorded in the open air of a shaded location
Aquatic	ah-KWA-tick	Living or active in or on water
Aragonite	uh-RA-guh-nite	A cave mineral, which often forms needle-like crystals
Asymptomatic	ay-sim-toe-MAT-tick	Showing no signs of a disease, disorder or other condition
Bachelor	BATCH-el-or	A young male animal that doesn't breed; in bats, bachelor colonies contain both non-breeding males and females
Baobab	BAY-oh-bab	A tree with a stout trunk up to 30 feet in diameter, with large, hanging flowers that are white and a hard-shelled fleshy fruit; found in tropical African savannas and provides food or shelter for many kinds of animals
Bat detector	BAT dee-TECK-tor	An electronic instrument used by bat researchers that translates the high-frequency echolocation call of bats into sounds that can be heard by humans
Bat excluder	BAT ex-CLUE-der	A person who specializes in removing colonies of bats from human buildings. (See also "Bat Rescuer")
Bat house	BAT HOUSE	A structure that is built to provide roosting habitat for bats; usually made from wood, having 3/4 inch wide roosting spaces inside, and an open bottom
Bat Rescuer	BAT RES-cu-er	A person who removes individual bats from human buildings, and also works to rehabilitate and release sick or injured bats. (See also "Bat Excluder")
Cacti; singular Cactus	CACK-tie	A large group of plants native to arid regions of the New World that have thick, fleshy, often prickly stems that function as leaves.
Calcar	CAL-car	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
Calcite	KAL-site	A common crystalline form of calcium carbonate.
Canine	CAY-nine	The tallest, pointed tooth located between the front teeth (incisors) and the shorter and broader pre-molars
Capacity	kuh-PAS-i-tee	The maximum amount or number that can be received or contained; cubic contents; volume:
Canopy	CAN-oh-pee	High, interlocking branches of large trees, as in a rain forest
Carnivore	CAR-nih-VORE	An animal which eats meat
Carnivorous	Car-NIH-ver-ess	Meat-eating
Cartilage	CAR-tih-laj	A tough, white tissue that attaches to the surfaces of bones where a bone connects with a tendon or where two bones meet

Cathedral	kuh-THEE-druh-l	Something that resembles a cathedral,as in grandeur or authority
Cave Fish	CAVE FISH	Fish found in caves and adapted to life in the dark, notably lacking eyes and pigmentation.Only three species of **cave fish** lack eyes completely, but several others have useless eyes. Only found in caves that have streams running into them.
Cave Coral	CAVE COR-al	Also known as "popcorn"; small knobby clusters formed by seeping water
Cave Flower, gypsum flower	CAVE FLOW-er	White gypsum "**Cave Flowers**" radiate outward from a **cave** wall. **Cave Flowers** can form when water, rich with minerals such as sulfate, seeps from the walls
Cave Pearl	CAVE PEARL	Small, almost spherical concretion of calcite that is formed in a pool of water in a cave and is not attached to the surface on which it forms
Chaparral	SHAP-ah-RAL	A scrubland habitat of dense, spiny, evergreen shrubs; characterized by mild, rainy winters and long , hot, dry summers
Chiroptera	k'eye-ROP-ter-ah	Taxonomic order containing all bats, the only flying mammals; from the Latin: "Chiro-" meaning hand-like and "-ptera" meaning wing
Chiropteran	k'eye-ROP-ter-en	Having to do with bats
Colony	COL-oh-nee	A group of the same kind of animals or plants living or growing together
Column	KOL-em	When a stalactite and a stalagmite grow together from the floor to the ceiling
Community	cah-MEW-nit-tee	All the organisms inhabiting a restricted area, such as a field, pond, or cave
Consumer	con-SOO-mer	An organism that feeds on other organisms or organic matter
Corpses	KORPS	A dead body, usually of a human being
Crepuscular	kree-PUS-queh-lar	Becoming active at twilight, near sunset or sunrise
Deciduous	dee-SID-you-us	A type of tree that loses its leaves annually, usually in the fall
Decomposer	DEE-com-PO-zer	An organism, especially bacteria or fungi, which breaks down non-living organic matter such as corpses, plant material, and the wastes of living organisms
Detritus	de-TRI-tus	Rock in small particles or other material broken away from a mass, as by the action of water or glacial ice
Detritivore	dee-TRIT-ih-vore	A special class of consumers, such as bacteria and fungi, that derives energy from organic wastes and dead organisms
Disperse	dis-PURSE	To scatter in various directions as in scattering seeds away from a parent plant
Diurnal	dye-UR-nal	To be active during the day (see also "Nocturnal")
Diverse	DIE-verse	Varied; of many types or kinds
Diversity	die-VERSE-ih-tee	Having a variety of different types; being distinct or unlike in kind, form, and / or function
Drapery	DRA-puh-ree	A speleothem formed when water deposits calcite in thin sheets that hang in delicate folds
Durian	DUR-ee-en	A tree found in southeastern Asia that bears fruit with a hard, prickly rind and soft, stinky yet pleasant-tasting pulp; also the name of the fruit.
Echidna	eh-KID-nah	A burrowing, egg-laying mammal with a spiny coat, slender snout, and sticky tongue for catching insects; found in Australia, Tasmania, and New Guinea; also known as the spiny anteater
Echolocate	ECK-coh-LOW-kate	The ability of an animal (mostly bats, porpoises, or whales) to find its way by listening to the echoes of sounds it produces
Echolocation	ECK-coh-Low-CAY-shun	The process by which an animal orients itself by listening to the echoes of the sounds that it has produced.

Ecologist	ee-CALL-oh-jist	A person who studies the relationships between living organisms and their environments
Ecosystem	EE-coh-SIS-tem	All the interacting organisms of a community and their non-living surroundings regarded as a unit
Ecotourism	ee-coh-TOOR-iz-um	The business of providing trips, vacations, and / or sight-seeing excursions to view wildlife and nature
Ectothermic	EK-tuh-THERM-ick	Cold-blooded; warming up the body by an external source of heat (such as the sun). See also "Endothermic"
Emerge	ee-MERJ	For bats, to leave a cave or other roost, usually at dusk
Emergence	ee-MER-jens	For bats, the act of leaving a cave or other roost, usually at dusk
Endangered	en-DANE-jurd	Threatened with extinction. Animals or plants that are at risk of going extinct
Endothermic	EN-doe-THERM-ick	Warm-blooded; warming up the body by an internal source of heat - energy from food. See also "Ectothermic"
Environment	en-VIE-ron-ment	The resources such as air, water, minerals, and living communities that surround and affect an organism, especially those that contribute to its growth and survival
Evolution	EV-oh-LOO-shun	Changes in the characteristics of a plant or animal species, over generations of time, that usually help them adapt to better survive the conditions where they live
Extinct	ex-STINGKT	No longer existing, as when the last individual of a plant or animal species dies
Extinction	ex-STINGKT-shun	The process of a species dying out to the point where no more are left
Fertilize	FUR-till-eyez	To provide soil with nutrients to aid the growth of plants
Fertilizer	FUR-till-eyez-er	Something that provides soil with nutrients to aid the growth of plants
Flowstone	FLOW-stone	Resembling frozen waterfalls, form when water flows down walls, over floors and older formations, building up sheets of calcite like icing on a cake.
Flying Fox	FLY-ing FOX	A fruit-eating bat having a dog-like face and ears; of the genus Pteropus, or the taxonomic sub-order Megachiroptera; found mostly in tropical Africa, Asia, Australia, or the South Pacific
Foliage	FOLE-ladj	Plant leaves as a whole; a cluster of leaves
Foliage Gleaning	FOLE-ladj GLEEN-ing	To hunt insects by scanning plants
Food chain	FOOD chain	A series of organisms, each eating or decomposing the preceding one, as when an insect eats a plant and then is eaten by a bat
Forage	FOR-age	To look for food
Forearm	FOR-arm	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
Free-Tailed	FREE-taled	A bat with a tail that is not attached to the patagium (wing membrane)
Frequency	FREE-quen-see	The amount of repetition of a cycle (such as a wave of sound) within a specified time period
Frigid	FRIJ-id	Very cold in temperature
Frugivore	FROO-gah-VORE	An animal which eats fruit
Frugivorous	Froo-GIVE-ver-ess	Fruit-eating
Fungal	FUN-gul	Pertaining to a fungus
Fungus; plural Fungi	FUN-gus	A plant-like organism, lacking chlorophyll, which obtains nutrients and energy by secreting enzymes that break down organic matter in living or dead organisms (See also "Detritivore")
Gestation	je-STAY-shun	The period of time that a baby is carried in the uterus

Guano	GWA-noh	Animal dropping or excrement, usually composed of seabird or bat droppings harvested and sold as fertilizer from islands where large numbers of birds breed or from caves where large numbers of bats roost
Habitat	HAB-ih-tat	The environment in which an organism or population of plants or animals lives; the normal kind of location inhabited by a plant or animal
Harmonize	HAR-muh-nize	
Helictites	HEE-lick-tites	Small twisted structures projecting from ceilings, walls and the floor of caves that seem to defy the laws of gravity. Formed by seeping water, they project at all angles.
Herbivore	ERB-ih-vore	An organism that eats plants, such as a rabbit or a cow
Hibernaculum	HIGH-bur-NACK-you-lum	A shelter for a hibernating animal, usually a cave or mine where bats hibernate in winter; plural Hiburnacula
Hibernate	HIGH-bur-nate	To pass the winter in a deep sleep in which the metabolism is extremely slow (see also "hibernation")
Hibernation	High-bur-NAY-shun	The act of passing the winter in a dormant state in which the metabolism is slowed to a tiny fraction of normal (see also "hibernate)
High Frequency	HIGH FREE-quen-see	A sound that is above the level of human hearing (see also "ultrasonic)
Histoplasmosis	HIST-toh-plaz-MOH-sis	A fungus that infects human lungs, causing respiratory illness; results from breathing spores of a certain fungus
Homeothermic	ho-MEE-oh-THUR-mick	Maintaining a nearly constant and warm body temperature regardless of environmental temperature; warm-blooded
Hypothesis	high-POTH-eh-sis	A statement considered to be true for the purpose of investigation or argument, and must be stated in a manner that can be tested and that could be proven false
Insectivore	in-SECK-tih-vore	Any animal that feeds mostly on insects
Kapok	KAY-pock	A silky fiber obtained from the seed pods of the silk-cotton tree; used for insulation and as padding in mattresses, pillows, and life preservers
Karst	CARst	An area or rock made of limestone in which erosion has produced cracks, sinkholes, or underground cavities such as caves
Keystone species	KEY-stone SPEE-seez	A central or supporting element in a habitat or ecosystem; an organism upon which numerous other plants and / or animals rely for food, shelter, growth, development and / or reproduction
Kilohertz	KILL-oh-hurts	A unit used to measure sounds; a thousand waves of sound (or echolocation calls) emitted in a second equals one kilohertz; while human sounds are mostly low (less than 1000 waves of sound per second, most bat sounds are high frequency (more than 2000 waves per second)
Larva; plural larvae	LAR-vuh	The wingless, often worm-like, juvenile or sexually immature forms of insects which undergo metamorphosis to become adults (as when a caterpillar becomes a butterfly)
Larynx	LARE-inks	The upper part of the respiratory tract that includes the vocal chords that enable vocalizations
Lift	LIFT	The force that keeps a flying animal (or machine) in the air; created by the upward motion of the bat's wings. See also "thrust"
Mammal	MAM-al	A class of vertebrate animals that includes more than 4,000 species, distinguished by self-regulating body temperature, hair, and in the females, mammary glands (breasts) to nurse their young
Mammary glands	MAM-uh-ree GLANDS	Glands that produce milk in female mammals

Massacred	MAS-sa-cred	Unnecessary, indiscriminate killing, especially in a large number
Maternity Colony	muh-TUR-ni-ty KOL-uh-nee	A special colony established by female bats in which to birth and raise the young
Maternity roost	mah-TURN-ih-tee ROOST	A location where mother bats go to give birth and nurse and care for young
Matriarch	MAY-tree-ark	A female who rules or dominates her family and descendants
Meditated	MED-uh-tay-ted	To think contemplatively; reflect
Megabat	MEG-ah-bat	see "Megachiroptera"
Megachiroptera	MEG-ah-k'eye-ROP-ter-ah	A suborder of bats containing about 173 species that have claws on both their thumbs and second fingers, also distinguished by large eyes, fox- or dog-like faces, and simple rounded ears; found only in the Old World tropics; called "megabats" or "flying foxes" (See also Michrochiroptera")
Membrane	MEM-brain	A thin, flexible layer of tissue covering surfaces, or separating of connecting regions, structures or organs of an animal of plant, including the two layers of skin from which bat wings are made
Metabolism	meh-TAB-oh-LIZ-um	The combination of chemical and physical processes required to maintain life, usually progressing most rapidly at higher body temperatures, as indicated by a rapid heart rate or fast breathing
Metacarpal	met-ah-CAR-pull	The five bones between the fingers and the wrist in the hand of a person, in the wing of a bat, or in the forelimb of an animal
Microbat	MY-crow-BAT	see "Microchiroptera"
Microchiroptera	MY-crow-k'eye-ROP-ter-ah	A suborder of bats containing about 813 species that have claws only on their thumbs, also distinguished by often complex facial structures and ears with a large tragus; found worldwide, also called "microbats. See also "Megachiroptera"
Migrate	My-grate	To change location periodically, especially to move seasonally from one region to another
Migration	My-GRAY-shun	The act of changing location, especially seasonally
Mist Net	MIST net	A very finely threaded net that is stretched between two poles to capture bats or birds
Myotis sodalis	my-OH-tis soh-DAL-is	Scientific name of the Indiana bat
Natural resources	NAT-ur-al REE-sore-suhs	Natural products that have value, such as timber, fresh water, or minerals
Navigate	NAV-vih-gate	To make one's way across a defined area; to travel
Nectar	NECK-tar	A sweet liquid secreted by most flowers to attract animal pollinators
Nectarivore	NECK-ter-ah-VORE	An animal that eats nectar (liquid found in flowers)
New World	NEW world	The western hemisphere; the region of the planet including North America, Central America, and South America, and nearby islands
Nocturnal	nock-TURN-ahl	Active only at night or having flowers that open only at night
Nose Leaf	NOSE leef	A triangular projection of flesh found on the noses of some Microchiropteran bat species, appears to function in directing echolocation signals emitted through the nose
Nursery colony	NUR-sir-ee COL-oh-nee	A group of animals that comes together to rear young
Old World	OLD world	The eastern hemisphere; the region of the planet including Europe, Asia, Africa, Australia and the Pacific and Indian Ocean islands
Omnivore	OM-nih-VORE	An organism that eats both plants and meat, such as a bear or coati
Parasite	PAIR-ih-site	An organism that feed on another organism while contributing nothing to the survival of its host; for example, fleas and ticks

Patagium	puh-TAY-jee-um	The wing membrane; a very strong layer of skin stretched across a bat's forearms and hands to form wings See also "Uropatagium"
Pesticide	PES-tih-side	A chemical used to kill animals, mostly insects, often harmful to humans as well
Phalanges	fah-LAN-geez	The long bones of the fingers or toes
Piper	PIE-per	A plant of the pepper family that produces fruit on uprights or hanging stalks
Piscivore	PISK-kah-vore	An animal which eats mainly fish
Plantain	plan-TAIN	A large tropical plant resembling a banana and bearing similar edible fruit
Pollen	PAUL-en	The fine powder-like material produced by the anthers of flowering plants that provides the source of the male elements (gametes) in fertilization
Pollinate	PAUL-en-ate	To carry pollen from male flowers to female flowers or to male and female parts of a single flower, either on the same plant or on different plants of the same species
Pollination	pol-uh-NA-shun	The transfer of pollen from one flower to another; this fertilized the flower
Pollinator	PAUL-en-ate-or	An animal that pollinates plants
Predator	PRED-ah-tore	An animal that lives by catching and eating other animals
Prey	PRAY	A creature hunted or caught for food
Primary consumer	PR'EYE-mare-ee pro-DOO-sir	Organisms that eat plants or algae, such as herbivores
Primary producer	TARE-oh-PO-did-day	Any organism that is capable of manufacturing its own food from inorganic materials, usually accomplished by plants that create new energy from a combination of inorganic materials and sunlight in a process known as photosynthesis
Pulses	PUHL-ses	The short sound patterns that bats make to echolocate
Pup	PUP	A baby or young bat
Rabies	RAY-beez	A disease caused by a virus; almost always fatal, usually transmitted by bites from mammals or through contact with infected saliva and / or nervous tissue; can be prevented by prompt vaccination
Rain Forest	RAIN fore-est	A dense, usually tropical, evergreen forest which receives heavy rainfall, more than 255 cm (100 inches) per year; generally found near the equator
Range	RANGE	The general (large-scale) area of the world where an animal is found. (See also "Habitat")
Rimstone Dams	RIM-stone dams	Steplike terraces along streams and on cave floors that enclose pools of water
Roost	ROOST	A place where a flying animal, usually a bird or bat, can sleep or rest, usually by perching or hanging
Saguaro	sah-WAR-oh	An extremely large cactus, three to twelve meters (10 to 40 feet) tall, of the southwestern United States and northern Mexico, with upward curving branches, white flowers, and red fruit
Sanctuaries	SANGK-choo-ER-ee	Immunity, as to arrest, afforded by refuge in any place providing refuge or asylum. A tract of land where wildlife can breed and take refuge in safety from hunters
Sanguivore	SAN-gua-VORE	An animal which eats mainly blood
Second-level consumer	SEK-und LEV-ul kuhn-SOO-mer	In a food chain, the organism, a carnivore, which eats herbivores
Seed dispersal	SEED dis-PER-sal	The process of scattering seeds away from the parent plant, usually by an animal that eats the fruit and thus increases the probability that the seed will grow into a new plant

Shields	SHEELDS	Flat semi-circular calcite sheets formed by water seeping from a thin crack. Stalactites and draperies commonly decorate the edges of these rare speleothems
Soda Straws	SOH-duh STRAWS	Thin hollow tubes that grow from the ceiling of caves as water runs down inside them and deposits rings of calcite at their tips
Sonar	SO-nar	A system by which transmitted sound waves and their echoes are used to locate unseen objects by animals that emit high frequency sounds from their mouths or noses; acronym for So(und) Na(vigation) R (anging)
Species	SPEE-seez	A group of related organisms that can mate and produce healthy offspring, typically similar in appearance
Speleothem	SPEE-lee-OH-them	Any mineral deposit or formation found in caves.
Spelunker	spi-LUNGK-er	A person whose hobby is exploring caves.
Stalactite	stuh-LACK-tite	An icicle like deposit that grows down from the cave ceiling. Stalactites form as calcite is deposited around the outside of soda straws after the centers of soda straws become plugged
Stalagmite	stuh-LAG-mite	Speleothems that grow up from the floor; usually formed by dripping water from stalactites above. They are more rounded on top than stalactites
Tail membrane	TAIL MEM-brain	The area of skin which joins the legs and / or tail of a bat
Taxonomy	tax-ON-ah-mee	The science of classifying organisms into categories of related kinds
Temperate	TEM-prit, or TEM-per-it	Neither extremely hot nor cold in climate, relatively mild; either of two middle-latitude zones of the earth lying between 23 1/2 and 66 1/2 degrees north and south of the equator
Terrestrial	tair-REST-tree-al	Of the earth or its land-dwelling inhabitants, growing or living on land
Terrestrial Acquisition	tuh-RES-tree-uhl AK-wi-ZISH-uhn	To hunt insects by scanning the ground while flying low
Third level consumer	THIRD LEV-ul kuhn-SOO-mer	In a food chain, a carnivore that eats another carnivore that ate a primary consumer
Thrust	THRUHST	The force that propels a flying animal (or machine) in the desired direction; created by the downward motion of the bat's wings. (See also "Lift")
Top level carnivore	top LEV-el CAR-ni-vore	In a food chain, a meat-eating organism that eats other meat-eaters that have eaten primary or second level or third level consumers
Torpor	TOR-pur	Mental or physical inactivity or sluggishness, resulting from lowered body temperature at levels part way between normally active and hibernation
Tragus	TRAY-gus	A tiny finger-like projection of skin-covered cartilage in front of a bat's ear
Trophic level	TROH-fick LEV-all	A feeding level in a food chain or food pyramid characterized by organisms that occupy a similar functional position as producers or consumers in an ecosystem
Ultrasonic	UHL-trah-SAWN-ick	Sound frequencies above the range that human ears can hear, or above approximately 20,000 cycles per second (20 kilohertz)
Uropatagium	YOOR-uh-puh-TAY-jee-um	The scientific term for "tail membrane;" skin connecting a bat's tail to its patagium (wing membrane). (See also "tail membrane")
Vaulted	VAHL-tid	Resembling an arched roof
Wingspan	WEENG-span	The distance between the tips of a bat's wings, across its body