United States Department of Agriculture
Forest Service
Sylamore Ranger District
1001 East Main
Mountain View, AR 72560
Phone 870-269-3228
FAX 870-269-3000

File Code: 2300

Date:

Dear Educator,

The Forest Service welcomes you to the cave world best known by the bat and the salamander. Although it seems to be a world apart, it is very much connected to our everyday world by the water that we drink and the soil beneath our feet. This packet of cave materials is intended to enrich your school group's visit to Blanchard Springs Caverns. These activities are also supposed to be fun, to be treated like educational games. The activities are aimed at 5th grade and up. They can be easily adapted to higher or lower level classes by adding or deleting the clues that are given. The upper right corner of each answer sheet notes the skills from the science curriculum guide for grades 4-6 that are taught for each activity. Copy the activity sheets as you need them for your students.

Before your visit, we encourage you to show the video "The Amazing World Below". It provides an excellent introduction to Blanchard Springs Caverns. You'll note on the following sheet that two games are designed to be used after the movie, but before your visit. The other activities are intended for use before or after the caverns tour. Each student will need to bring a pencil.

You will want to make reservations for your tour by calling or writing ahead. With reservations you qualify for the group rate as long as you have fifteen or more people for the caverns tour. Details of the group policy are enclosed. Nearby the Caverns is a recreation area with picnicking, swimming, camping, and hiking.

We encourage your comments and suggestions to make this packet work better for you. Please feel free to call either 1-888-757-2246 or 870-757-2211 if you have any questions. Happy discovery!

Sincerely,

William R. Reeves
Caverns Administrator/ORP

For the Educator: Ideas and Suggested Use of the Packet

United States Department of Agriculture | Forest Service | Sylamore Ranger District | 1001 East Main
Mountain View, AR 72560
Phone 870-269-3228
FAX 870-269-3000

File Code: 2300

Date:

Dear Educator,

The Forest Service welcomes you to the cave world best known by the bat and the salamander. Although it seems to be a world apart, it is very much connected to our everyday world by the water that we drink and the soil beneath our feet. This packet of cave materials is intended to enrich your school group's visit to Blanchard Springs Caverns. These activities are also supposed to be fun, to be treated like educational games. The activities are aimed at 5th grade and up. They can be easily adapted to higher or lower level classes by adding or deleting the clues that are given. The upper right corner of each answer sheet notes the skills from the science curriculum guide for grades 4-6 that are taught for each activity. Copy the activity sheets as you need them for your students.

Before your visit, we encourage you to show the video "The Amazing World Below". It provides an excellent introduction to Blanchard Springs Caverns. You'll note on the following sheet that two games are designed to be used after the movie, but before your visit. The other activities are intended for use before or after the caverns tour. Each student will need to bring a pencil.

You will want to make reservations for your tour by calling or writing ahead. With reservations you qualify for the group rate as long as you have fifteen or more people for the caverns tour. Details of the group policy are enclosed. Nearby the Caverns is a recreation area with picnicking, swimming, camping, and hiking.

We encourage your comments and suggestions to make this packet work better for you. Please feel free to call either 1-888-757-2246 or 870-757-2211 if you have any questions. Happy discovery!

Sincerely,

William R. Reeves
Caverns Administrator/ORP

For the Educator: Ideas and Suggested Use of the Packet

At Blanchard Visitor Center

You should plan on being at the Visitor Center 30 minutes before your tour time. If you have already seen the movie, your group will have time to use the restrooms and see the exhibit hall before your tour.

Activities:

- The "Exploring the Exhibit Hall" activity sheets are designed to be used in the exhibit hall to promote better understanding and encourage some active reading of the displays. All of the questions can be answered from the exhibit information. Some concepts such as "adaptations" may be new and need more explanations.
- The "Most Dangerous Animal" sheet can be used before or after the tour. Most of the sheet can be answered from information in the exhibit hall. The concept that you may not touch the cave rocks or formations is stated in the exhibits. We would appreciate your stressing that rule. We may not touch cave rocks because the oil from our skin can damage the formations by stopping water from depositing calcite. In fact our skin oil actually "kills" the active formations. This rule is emphasized at the beginning of every cave tour.
- The energy maze "Follow the Flow" is intended as a game to reinforce some of the concepts introduced in previous activities. You can make the puzzle easier by giving the first letter in each word, or solving the clues as a class, then letting the individual find the words.

Suggested Additional Projects and Activities:

- Create-A-Cave
  Divide class in groups to create their own cave with formations made of clay or salt-and-flour dough.
- Be A Specialist
  Divide class in three groups to report to the group on Blanchard Springs Caverns from the standpoint of a biologist, geologist, and hydrologist.
- Write
  Write essays or poems focusing on caves and cave life.

Projects

To be assigned before visit: Work individually or in groups to further research and report on specific aspects of Blanchard Springs Caverns. The projects could be written reports, bulletin boards, drawings, models, etc.

Suggested topics:

- How was Blanchard Springs Caverns formed?
- Learn more about bats. Discuss reproduction, navigation, conservation, different species, etc.
- Describe the three zones in a cave and the plants and animals found in each.
- How are cave formations made? What different kinds are there?
- Cave conservation – how human activity can damage caves and cave life; what can be done to prevent damage.

Introduction: "The Amazing World Below"
Showing the 20-minute movie is an excellent way to introduce the idea of caves and cave life. For many this is a totally new realm filled with mystery, awe, and perhaps fear. After the movie, try discussing the similarities and differences about the cave compared to our surface world.

- Differences: The cave is dark, maintains a constant temperature and humidity year-round (Blanchard is about 58 degrees). There is no weather, no sunshine, no energy, and little food. Animals are specially adapted to cave life, etc.
- Similarities: Natural laws are the same – animals that live in the cave have the same needs as those on the surface: air, pure water, food (energy) and living space. Cave air is the same as surface air since air comes through the cracks and crevices that the water passes through. The cave temperature is an average of the annual surface temperature, etc.

Activities

- The Cavern History Mystery will help reinforce the geologic sequence of events that led to the formation of Blanchard Springs Caverns. The "Geology of BSC" handout will provide additional information.
- The Flying Mammal Connect the Dots will ease some of the anxiety about bats. Experience has shown that there are more questions and misinformation about bats than any other cave-related topic. Do stress that real bats are timid and mild-mannered and quite unlike the evil, vicious animals shown on horror films. Bats are not blind, contrary to the popular saying. Vampire bats do exist, but not in the United States. Although vampire bats feed on blood, they are small bats that creep up to sleeping animals, especially cattle. If the large animal doesn't stir, the bat will make a small cut on the animal's foot and lap up the drops of blood with its tongue. It's also true that bats might carry rabies. However, in Arkansas, rabies is the most frequently reported in skunks, foxes, cattle and dogs. Of course, no one should handle a bat, especially one that's on the ground. That's true of any wild animal. The section on bats will provide additional material. There are many good references to learn more about bats, including:

Barbour, Roger W. and W. H. Davis, Bats of America, The University Press of Kentucky, Lexington, 1969.

Fenton, M. Brock, Just Bats, University of Toronto Press, 1984

Harvey, Michael J., Arkansas Bats: a Valuable Resource, Arkansas Game and Fish Commission, 1986.

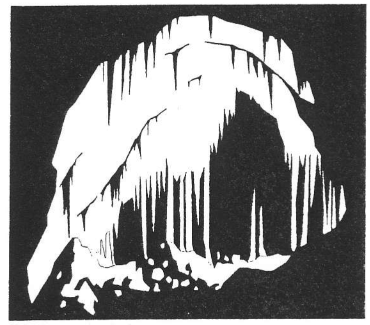
Johnson, Sylvia, A., The World of Bats, Learner Publications Company, Minneapolis, 1985.

Mohr, Charles E., The World of Bats, J. B. Lippincott and Co., Philadelphia, 1976

You'll undoubtedly find more books, and there are many that are written especially for children. You'll find a lot of good information on the Internet, so check various websites, or type "bats" into a search engine.

Exploring the Exhibit Hall

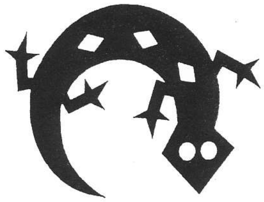
Cave Section



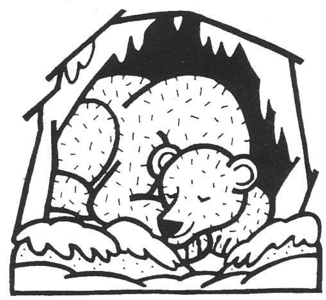
- Have you ever walked into a cave? Just inside the cave entrance the environment becomes ________ and __________, although it's not totally dark.
- Shells mixed with organic matter and mud compressed together to create ______________.
- What are cave formations made of? ______________________________.
- What two things allow water to drip through rock? ____________ and ______________
- Can you name two zones of a cave? ______________________, ______________________.
- Can you name some kinds of cave formations? ____ ____.
- Why shouldn't you touch the cave? ______________________________ ____.

Animal Section:

- There are three groups of animals at Blanchard. Can you name them? ______________ are a small population of true cave animals that are born, live and die without ever seeing sunlight. ____________ are not true cave dwellers. __________________ are cave lovers. Without the sun, food energy is scarce. Some cave critters have adjusted to their dark home through several adaptations. Note their color and size, what senses they depend on, how they move. How are these animals different from those on the surface? What are their adaptations?______________________ ______________________ ______________________ ______________________ ______________________.



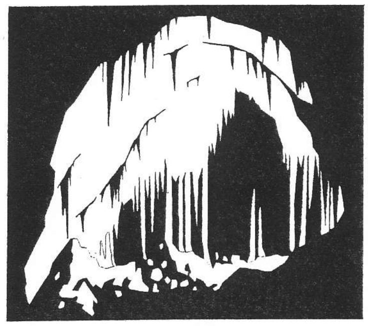
- What amphibian with a tail might live in a cave? ______________________________.
- Could a bear, a fox, or a snake survive deep in a cave? ____________________



Exploring the Exhibit Hall

Cave Section

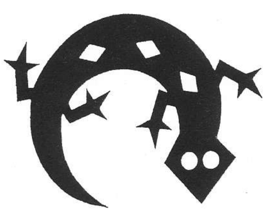
- Have you ever walked into a cave? Just inside the cave entrance the environment becomes COOL and DAMP, although it's not totally dark.



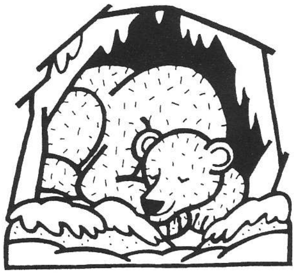
- Shells mixed with organic matter and mud compressed together to create LIMESTONE.
- What are cave formations made of? CALCITE OR CALCITE CRYSTAL.
- What two things allow water to drip through rock? CRACKS and FISSURES
- Can you name two zones of a cave? ENTRANCE, TWILIGHT, TOTAL DARKNESS.
- Can you name some kinds of cave formations? STALACTITES, STALAGMITES, COLUMNS, DRAPERIES, CURTAINS, SODA STRAWS
- Why shouldn't you touch the cave? OUR SKIN OILS GET DEPOSITED ON THE FORMATIONS; IT'S HARD FOR CALCITE TO FORM OVER THE OIL WE LEAVE BEHIND, SO OILS CAN STOP FORMATIONS FROM GROWING.

Animal Section:

- There are three groups of animals at Blanchard. Can you name them? TROGLOBITES are a small population of true cave animals that are born, live and die without ever seeing sunlight. TROGLOXENES are not true cave dwellers. TROGLOPHILES are cave lovers. Without the sun, food energy is scarce. Some cave critters have adjusted to their dark home through several adaptations. Note their color and size, what senses they depend on, how they move. How are these animals different from those on the surface? What are their adaptations? BLIND; COLORLESS; MORE SENSITIVE TO MOVEMENT; LONGER ANTENNAE; SLOWER; ABLE TO LIVE ON WHAT THEY FIND IN THE CAVE; SMALLER

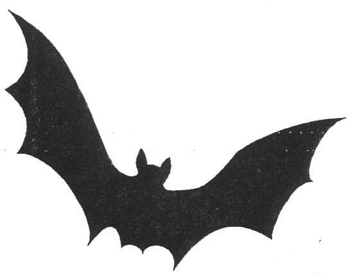


- What amphibian with a tail might live in a cave? SALAMANDER.
- Could a bear, a fox, or a snake survive deep in a cave? NO; BEARS DO HIBERNATE IN SHALLOW CAVES



Bats:

- The _______________ bat and the ____________________ bat are endangered species.
- Bats are ______________ __________________ that nurse their young.
- Bats in Arkansas eat_________, ______________, and _____________.
- _________________is the basis of the cave's food pyramid.
- A bat navigates and catches insects with a sonar-like process, called _________________.

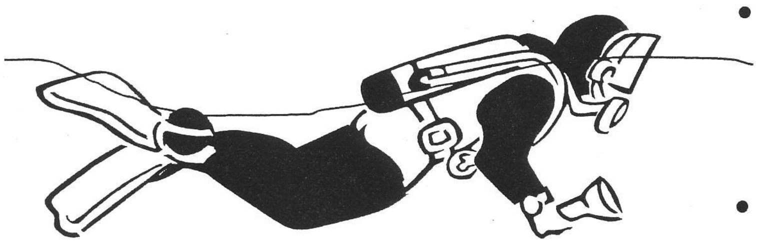


True or False?

- Bats will fly into your hair. __________
- All bats roost in caves. _____________
- Bats are not blind. _________________
- There are vampire bats in the United States. ______________

Caving and Cavers:

- Did Native Americans use caves? Why or why not?
  ____
  ____
- If you go wild caving, __________________ _______ __________________.
- How can we protect caves?____, ____________________________________, ______________________________.



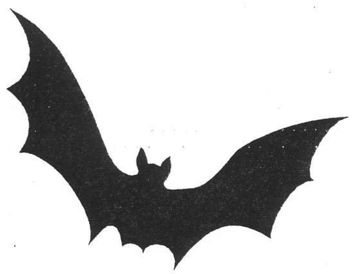
- What "adaptation" allowed man to explore the water-filled passages of Blanchard Springs? ____________________________.
- What animal is most dangerous to the cave? _______________________

Mitchell Mill and Local History Section:

- Settlers used the Springs' water to ___________their mills.
- The mills were used to ________ __________and _____________ ___________.
- What is a "flume"? ____
  ____.
- Name some other things that people did at the mill. ______________________
  ____.
- The Civilian Conservation Corps ____________ trees and ____________ trails.

Bats:

- The ___GRAY_____ bat and the ___INDIANA______ bat are endangered species.
- Bats are HAIRY (WARM BLOODED)_ MAMMALS__ that nurse their young.
- Bats in Arkansas eat GNATS, MOSQUITOES, and MOTHS (INSECTS).
- __BAT GUANO (OR DROPPINGS)__ is the basis of the cave's food pyramid.
- A bat navigates and catches insects with a sonar-like process, called __ECHOLOCATION___.

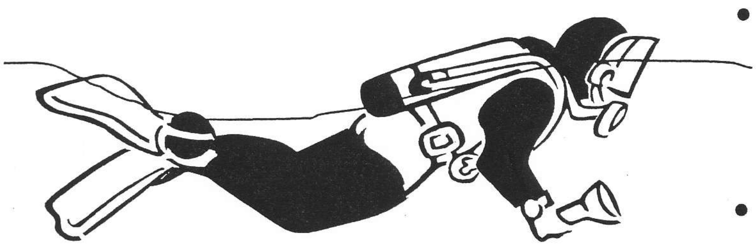


True or False?

- Bats will fly into your hair. _F_________
- All bats roost in caves. ___F__________
- Bats are not blind. ______T___________
- There are vampire bats in the United States. _____F_________

Caving and Cavers:

- Did Native Americans use caves? Why or why not? _YES, TO LIVE IN FOR SHORT PERIODS, TO GET CLAY, TO GET WATER, TO GET OUT OF BAD WEATHER_______________________________
- If you go wild caving, ____NEVER______ __GO___ ___ALONE__________.
- How can we protect caves?_STOP POLLUTION, SAVE THE BATS, WALK LIGHTLY (ALSO TAKE NOTHING BUT PICTURES, LEAVE NOTHING BUT FOOTPRINTS, KILL NOTHING BUT TIME).



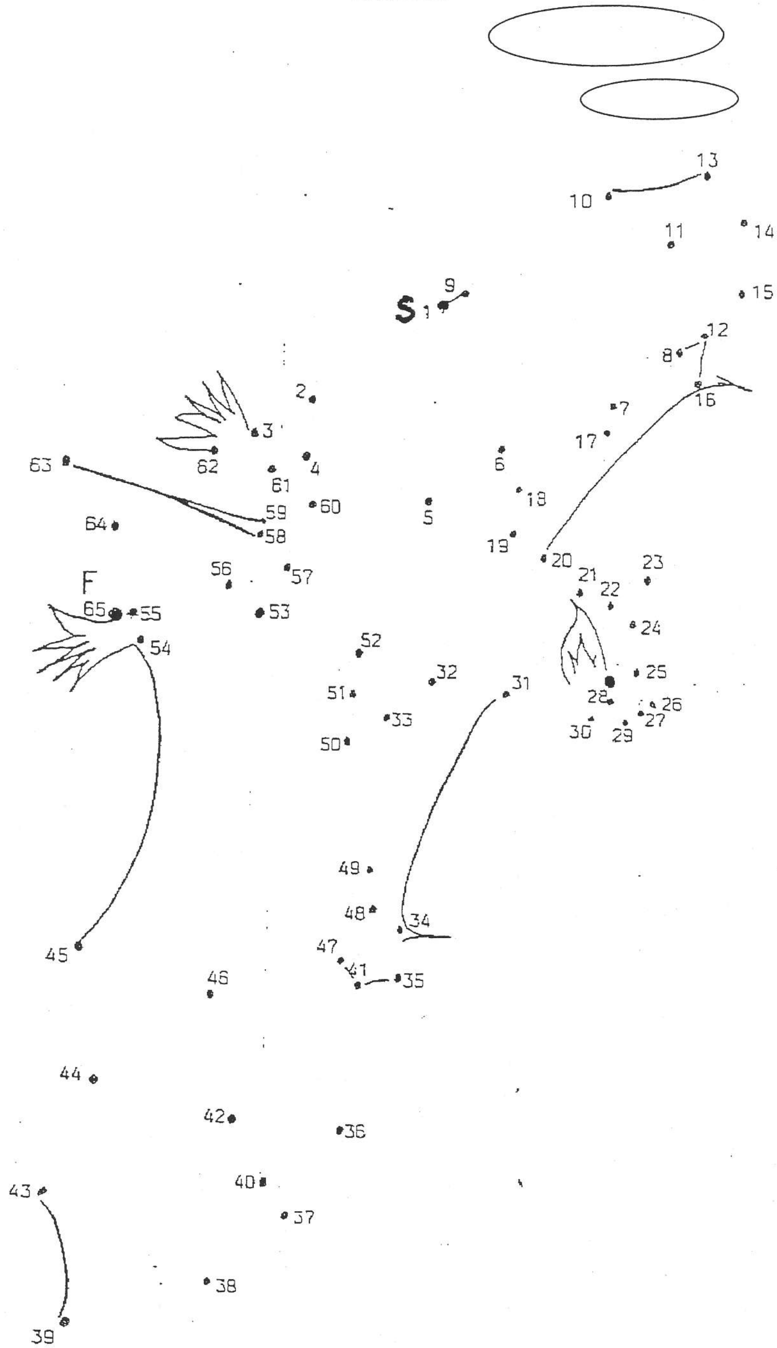
- What "adaptation" allowed man to explore the water-filled passages of Blanchard Springs? _SCUBA DIVING GEAR__.
- What animal is most dangerous to the cave? __PEOPLE__

Mitchell Mill and Local History Section:

- Settlers used the Springs' water to __POWER_their mills.
- The mills were used to _GRIND_ _ _CORN_and ___GIN_ _COTTON____.
- What is a "flume"? _A WOODEN TROUGH USED TO BRING WATER FROM THE DAM TO THE MILL'S WATERWHEEL_______________________
- Name some other things that people did at the mill. BRING TOOLS TO THE BLACKSMITH"S, VISIT WITH NEIGHBORS____________________
- The Civilian Conservation Corps _PLANTED_ trees and _BUILT_ trails.

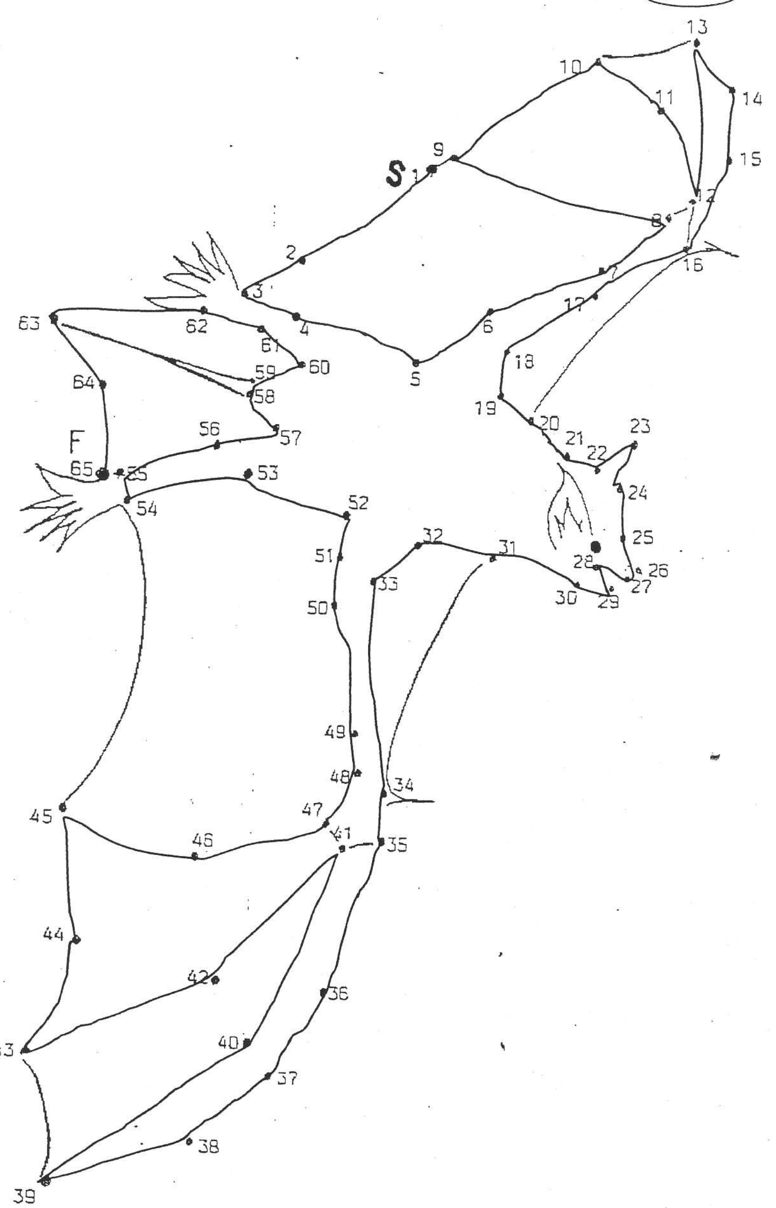
The Only Flying Mammal!

"Hi! I'm one of the animals that lives in Blanchard Springs Caverns. I'm a great flyer, but I don't have feathers. I'm a mammal, just like you are. I have fur and feed my babies with milk. I'm a shy creature, so most people don't get to see me during a cave tour."



The Only Flying Mammal!

"Hi! I'm one of the animals that lives in Blanchard Springs Caverns. I'm a great flyer, but I don't have feathers. I'm a mammal, just like you are. I have fur and feed my babies with milk. I'm a shy creature, so most people don't get to see me during a cave tour."



Draw the most dangerous animal to the cave






How can we help protect caves and cave life?

Clues: DISTURB LITTER POLLUTE FORMATIONS TOUCH NAME

- Never collect ___ ___ ___ ___ (6) (1) ___ ___ ___ ___ - that's a selfish hobby since they can never be repaired and it denies other people from seeing their beauty.
- Never ___ ___ ___ ___ ___ (2) ___ or carve your ___ (3) ___ ___. Always follow the rule "Take nothing but pictures, leave nothing but footprints, kill nothing but time."
- Don't ___ ___ ___ (10) ___ ___ (7) cave life . Respect the right for these harmless, unique animals to live in peace.
- Never ___ ___ ___ (4) (5) the cave rocks. Our skin oils will prevent the crystals from growing larger.
- Don't ___ (8) ___ ___ (9) ___ ___ the cave opening with trash. That could cause an interruption to the food web and damage the water quality.

Use the circled letters to complete this idea to help protect caves:

(1) (2) (3) (4) (5) others (6) (7) (8) (9) (10) caves!

Draw the most dangerous animal to the cave






How can we help protect caves and cave life?

Clues: DISTURB LITTER POLLUTE FORMATIONS TOUCH NAME

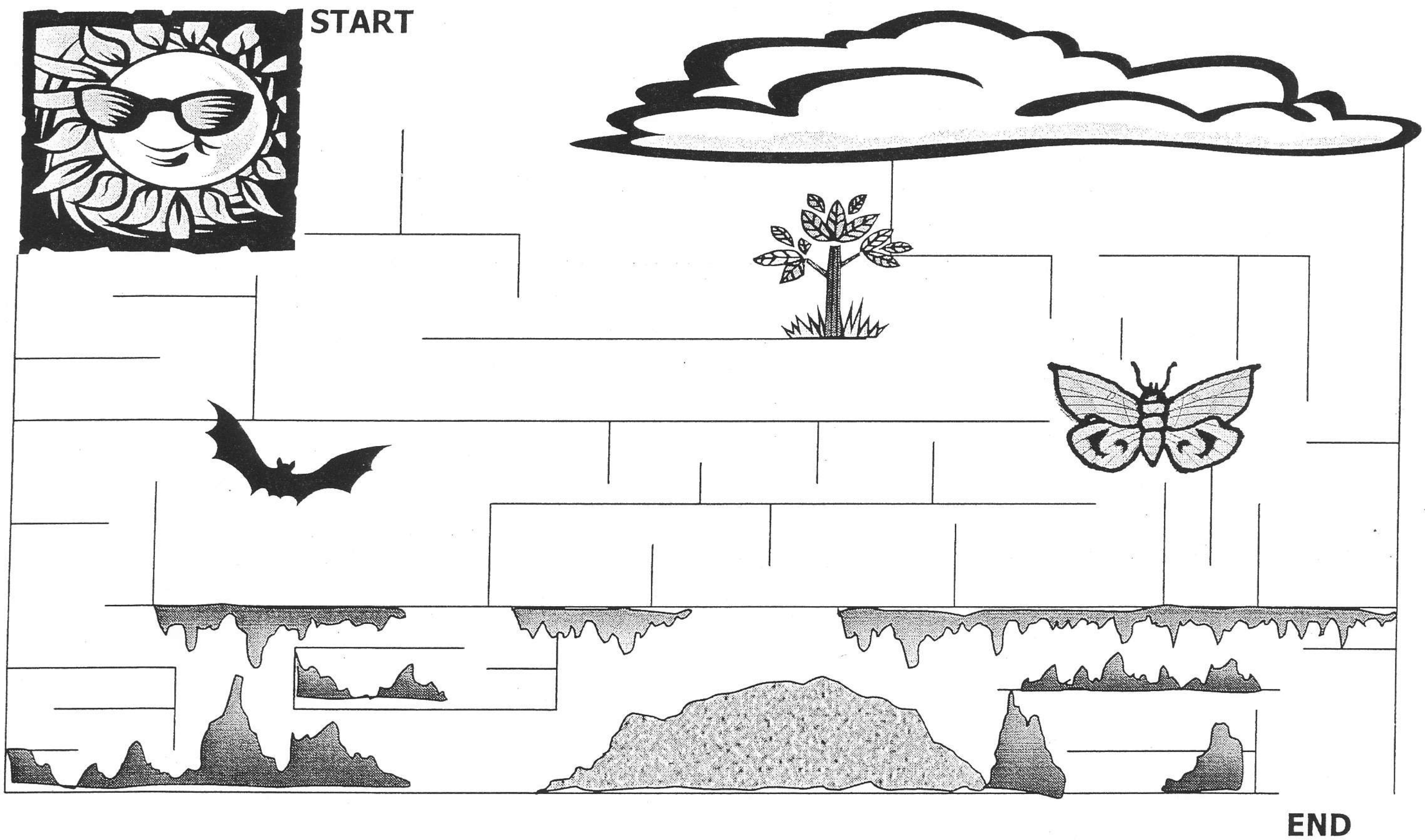
- Never collect F O R M A T I O N S - that's a selfish hobby (A = 6, T = 1) since they can never be repaired and it denies other people from seeing their beauty.
- Never L I T T E R (E = 2) or carve your N A M E (A = 3). Always follow the rule "Take nothing but nothing but pictures, leave nothing but footprints, kill nothing but time."
- Don't D I S T U R B (T = 10, B = 7) cave life. Respect the right for these harmless, unique animals to live in peace.
- Never T O U C H (C = 4, H = 5) the cave rocks. Our skin oils will prevent the crystals from growing larger.
- Don't P O L L U T E (O = 8, T = 9) the cave openings with trash. That could cause an interruption to the food web and damage the water quality.

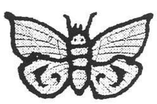
Use the circled letters to complete this idea to help protect caves:

T E A C H (1 2 3 4 5) others A B O U T (6 7 8 9 10) caves!

Follow the Flow

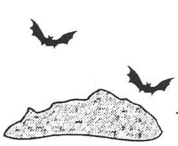
All living things need energy. We all get our energy from the food we eat. In the darkness of a cave, there is nothing we would consider food. And yet, Blanchard Springs Caverns is home for dozens of tiny, fascinating animals. What do they eat? Where do they get their energy? See how energy enters the cave by following the maze without crossing any lines. Then number the following things in the order you encountered them in the maze. Read the statements in order and you'll follow the flow of energy.



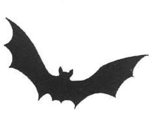


________Many kinds of **insects** eat green plants.

________The **sun** is the ultimate source of all energy. Even gasoline is really concentrated sunshine!



________ Bat droppings, called "**guano**", provide a source of energy for cave animals that live without sunlight.

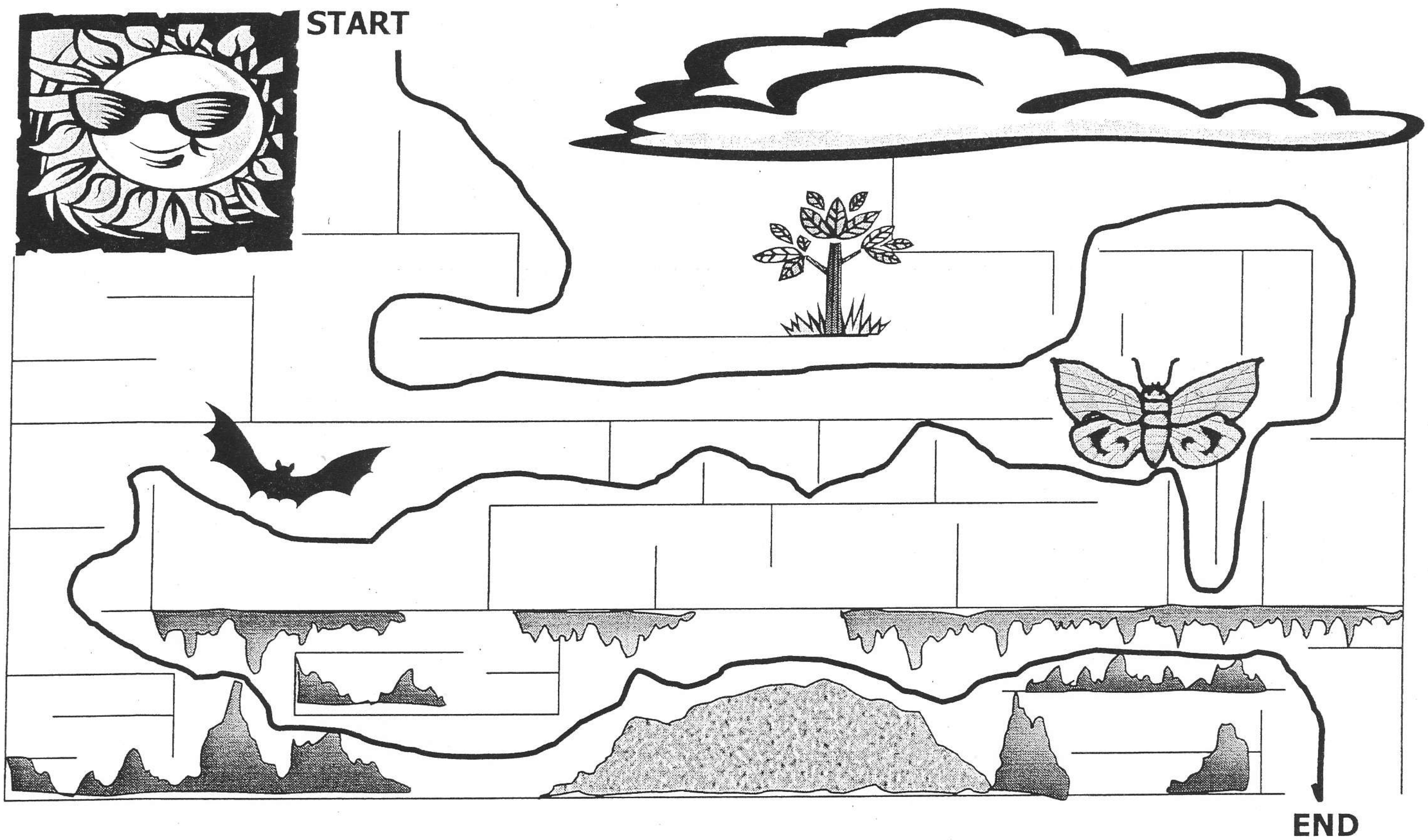


________ **Bats** eat night-flying insects.

________ Green plants are the only living things that can turn the sun's energy into food through a process called **photosynthesis**.

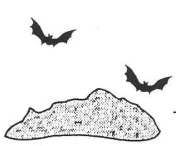
Follow the Flow

All living things need energy. We all get our energy from the food we eat. In the darkness of a cave, there is nothing we would consider food. And yet, Blanchard Springs Caverns is home for dozens of tiny, fascinating animals. What do they eat? Where do they get their energy? See how energy enters the cave by following the maze without crossing any lines. Then number the following things in the order you encountered them in the maze. Read the statements in order and you'll follow the flow of energy.

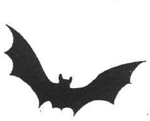


___3___ Many kinds of **insects** eat green plants.

___1___ The **sun** is the ultimate source of all energy. Even gasoline is really concentrated sunshine!



___5___ Bat droppings, called "**guano**", provide a source of energy for cave animals that live without sunlight.

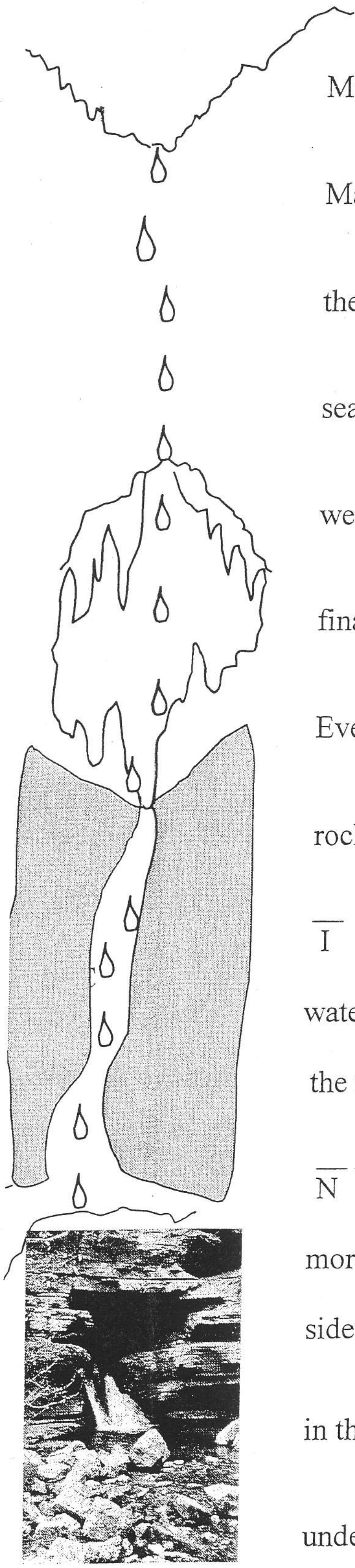


___4___ **Bats** eat night-flying insects.

___2___ Green plants are the only living things that can turn the sun's energy into food through a process called **photosynthesis**.

Cave History Mystery

Unravel the cave history words to solve the mystery below. Use the letters in the triangles and circles to finish the last two lines.



Millions of years ago nearly all of the United States was under a shallow ___ ___ ___ ○ ___.
NE C A O

Many forms of sea life lived here, including strangely shaped water animals who used

the lime that's dissolved in sea water to make ___ ○ ___ ___ ___ homes. As eons passed, the
L E H S L

sea life died and their homes piled up on the sea ___ △ ___ ___ ___. Those at the bottom
R O L O F

were crushed by the ___ ___ ___ ___ △ ___ of the ones that followed. Pressure from above
G E T H I W

finally pressed them together into a kind of rock called ___ △ ___ ___ ___ ___ ___ ___ ___ .
E M O L I N E T S

Eventually the sea bed was uplifted, forming the Ozark ___ ___ ___ ○ and exposing the
M E D O

rocks that had been underwater to surface elements - - wind, changing temperatures, and

___ ___ ___ ○. In time the mountains were shaped and valleys were formed. Meanwhile,
I N A R

water, charged with a mild carbonic ___ ___ △ ___, seeped down through tiny cracks in
C I A D

the rock. Formed as rain absorbs carbon dioxide from the air and soil,

___ ___ ___ ___ ___ △ ___ ___ acid is the main sculptor of ○ ___ ___ ___ ___. As it rained
N A R C I B O C   V E S C A

more, water moved in to enlarge openings and deepen them dissolving downward and

sideways in the limestone ___ ___ ___ ___. Ultimately, some of the water made an outlet
C O K R

in the side of the mountain and burst forth as a ○ ___ ___ ___ ___ ○. Slowly the
N I P S R G

underground cavity drained and a ___ ___ △ ___ ___ ___ was born. Blanchard Springs
N E V C R A

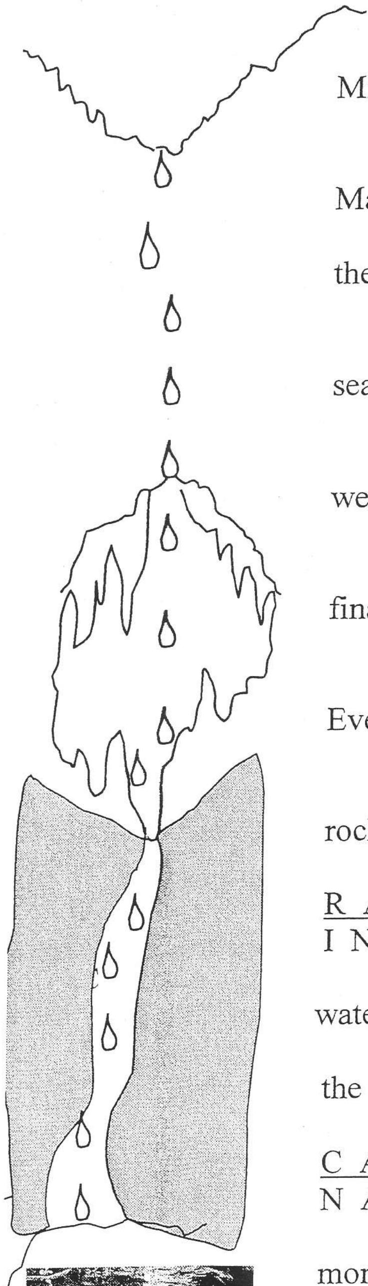
Caverns is called a △△△△△△ cave because as water enters, the cave

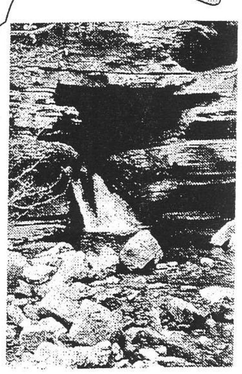
continually ○○○○○○○ .

Cave History Mystery

SCI (4-6) Skills: 11.1, 11.2, 11.3

Unravel the cave history words to solve the mystery below. Use the letters in the triangles and circles to finish the last two lines.





Millions of years ago nearly all of the United States was under a shallow O C E A N.
N E C A O

Many forms of sea life lived here, including strangely shaped water animals who used

the lime that's dissolved in sea water to make S H E L L homes. As eons passed, the
L E H S L

sea life died and their homes piled up on the sea F L O O R. Those at the bottom
R O L O F

were crushed by the W E I G H T of the ones that followed. Pressure from above
G E T H I W

finally pressed them together into a kind of rock called L I M E S T O N E.
E M O L I N E T S

Eventually the sea bed was uplifted, forming the Ozark D O M E and exposing the
M E D O

rocks that had been underwater to surface elements - - wind, changing temperatures, and

R A I N. In time the mountains were shaped and valleys were formed. Meanwhile,
I N A R

water, charged with a mild carbonic A C I D, seeped down through tiny cracks in
C I A D

the rock. Formed as rain absorbs carbon dioxide from the air and soil,

C A R B O N I C acid is the main sculptor of C A V E S. As it rained
N A R C I B O C V E S C A

more, water moved in to enlarge openings and deepen them dissolving downward and

sideways in the limestone R O C K. Ultimately, some of the water made an outlet
C O K R

in the side of the mountain and burst forth as a S P R I N G. Slowly the
N I P S R G

underground cavity drained and a C A V E R N was born. Blanchard Springs
N E V C R A

Caverns is called a L I V I N G cave because as water enters, the cave

continually C H A N G E S.

Cave Word Search

Search for the cave words hidden below. Words may be horizontal, vertical, or diagonal, and may read backwards. Use these clues to find the words:

- The only flying mammal:__ __ __
- This endangered bat shares its name with a state:__ __ __ __ __ __ __
- Bats eat thousands of __ __ __ __ __ __ __.
- A blind __ __ __ __ __ __ __ __ looks like a small white lobster.
- A lizard-shaped amphibian: __ __ __ __ __ __ __ __ __ __
- The main source of food energy in the cave, thanks to the bats: __ __ __ __ __
- Blanchard Springs Caverns is located in the __ __ __ __ __ Mountains.
- Blanchard Springs Caverns is operated by the F__ __ __ __ __ S__ __ __ __ __ __.
- Principal rock of the cave: __ __ __ __ __ __ __ __ __
- Formation that hangs down from the ceiling: __ __ __ __ __ __ __ __ __ __
- Formation that rises up from the ground: __ __ __ __ __ __ __ __ __ __
- The mineral that all formations are made from: __ __ __ __ __ __ __
- "Mites" and "tites" grow together to make a __ __ __ __ __ __.
- Please don't __ __ __ __ __ the cave rock.

BONUS WORD: The proper word for a cave formation: __ __ __ __ __ __ __ __ __ __

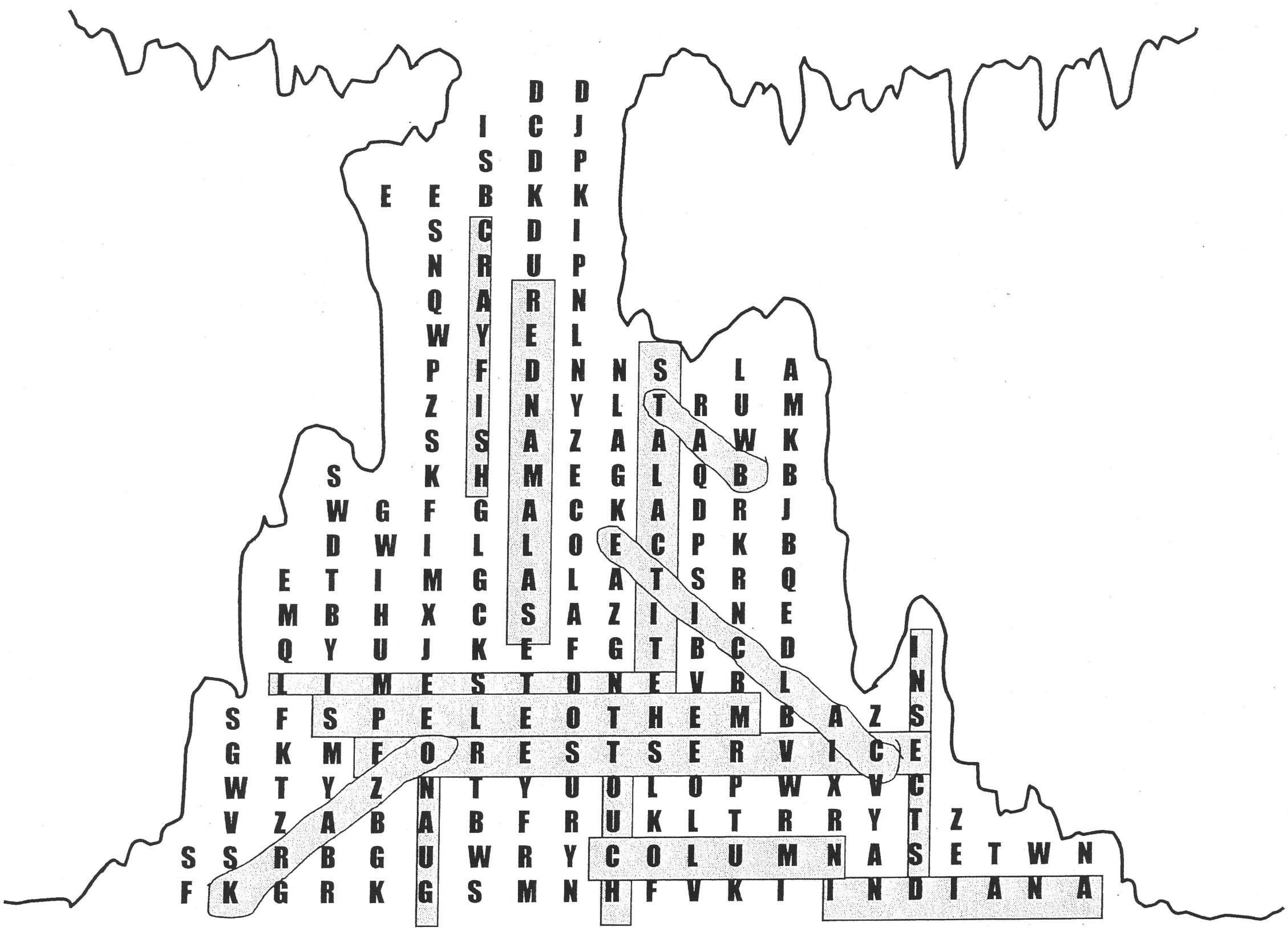
							D	D												
						I	C	J												
						S	D	P												
				E	E	B	K	K												
					S	C	D	I												
					N	R	U	P												
					Q	A	R	N												
					W	Y	E	L												
					P	F	D	N	N	S		L	A							
					Z	I	N	Y	L	T	R	U	M							
					S	S	A	Z	A	A	A	W	K							
			S		K	H	M	E	G	L	Q	B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

Cave Word Search

Search for the cave words hidden below. Words may be horizontal, vertical, or diagonal, and may read backwards. Use these clues to find the words:

- The only flying mammal: B A T
- This endangered bat shares its name with a state: I N D I A N A
- Bats eat thousands of I N S E C T S .
- A blind C R A Y F I S H looks like a small white lobster.
- A lizard-shaped amphibian: S A L A M A N D E R
- The main source of food energy in the cave, thanks to the bats: G U A N O
- Blanchard Springs Caverns is located in the O Z A R K Mountains.
- Blanchard Springs Caverns is operated by the F O R E S T S E R V I C E .
- Principal rock of the cave: L I M E S T O N E
- Formation that hangs down from the ceiling: S T A L A C T I T E
- Formation that rises up from the ground: S T A L A G M I T E
- The mineral that all formations are made from: C A L C I T E
- "Mites" and "tites" grow together to make a C O L U M N .
- Please don't T O U C H the cave rock.

BONUS WORD: The proper word for a cave formation: S P E L E O T H E M



Blanchard Springs Caverns

All the Water in the World

Objectives:

Using this Project WILD activity, students will:

- calculate the percentage of freshwater available for human use
- explain why water is a limited resource.

Arkansas Frameworks: ESS.8.4.1, ESS.8.4.6, ESS.8.4.7, ESS.8.7.8, ESS.8.7.14, ESS.8.7.16, ESS.8.7.17

Materials:

- 1-L container (a soda bottle will work)
- 100-ml graduated cylinder
- eyedropper
- ice cube tray
- small container (a dish will work)
- colored markers
- drawing paper
- salt

Background:

Students may know the earth is covered mainly by water, but they may not realize that only a small fraction is available for human consumption. Learning that water is a limited resource helps students appreciate the need to use water resources wisely and to protect wetlands, watersheds, caves, and groundwater.

Procedure:

1. Tell the students that they are going to estimate the proportion of drinkable (potable) and non-potable water on the planet. Discuss what makes water unavailable for human consumption. (Saltwater, water trapped in glaciers, pollution, etc.)
2. Break students into small groups. Have each group draw a large circle with a marker on a white sheet of paper.
3. Have each group draw a pie chart showing their estimates of potable and non-potable water.
4. Show the class a liter of water and tell them it represents all the water in the world. Ask where most of the water on earth is located (the oceans). Refer to a globe or map if necessary. Pour 30 ml of the water into a 100-ml graduated cylinder. This represents the

earth's freshwater, about 3 percent of the total. Put salt into the remaining 970 ml to simulate water found in oceans, unfit for human consumption.

5. Ask where most of the remaining water might be. Almost 80 percent of the earth's freshwater is frozen in ice caps and glaciers. Pour 6 ml of fresh water into a small dish and place the rest (24 ml) in an ice tray. The water in the dish (around 0.6 percent of the total) represents non-frozen freshwater.
6. Ask students where some of the rest of the water might be trapped. 4.5 ml of the water is underground. Fifty percent of the people in the United States get their drinking water from underground wells, but not all of the groundwater is reachable.
7. Using an eyedropper, remove a single drop of water (0.003 ml) from the dish and drop it into someone's hand. This represents clean, fresh surface water (from lakes and streams) which is not polluted or otherwise unavailable for use. This is about 0.00003 percent of the total! This precious drop must be managed properly.
8. Ask students to compare their original pie graph with what they just learned.

Wrap up:

Discuss the results of the demonstration. At this point students should conclude that a very small amount of water is available for human use. Remind the class of their earlier guesses at how much water is available to humans and compare with the actual percent available. Have students explain their reasoning for their initial estimates. Discuss whether or not there is enough water available for the current population. There are 8.4 million liters of water available for each of the 6 billion people on earth. Theoretically, this exceeds the amount of water one person would require in a lifetime. So, why does more than one third of the population not have access to clean water? Discuss the main factors affecting water distribution on earth. Students can also consider that other organisms use water. Discuss what the class can do with the water used in this demonstration to keep from wasting it.

Printed with permission from Wind Cave National Park from
http://www.nps.gov/archive/wica/Hydrology_Introduction_Why_Water.htm on 6-23-09.

BAT FACTS

Did you know that bats are mammals and, as such, have fur, regulated body temperature, a well-developed nervous system and are capable of learning? They also bear their young alive and nourish them with milk. Bats are the only mammals that can truly fly.

Bats are believed to come from a primitive stock of mammals, the Insectivora (insect eaters), represented today by shrews and moles. Despite their mouse-like appearance, bats are not rodents, but are classified in the order Chiroptera (ky-ROP-ter-a), which is taken from two Greek words meaning "hand-winged."

TYPES OF BATS

In the United States, there are about 40 different species of bats. Worldwide, at least 847 species are known. Bats rank second among mammals in the total number of species classified. Only rodents outrank bats.

The world's largest bat, a flying fox from New Guinea, was found to have a wingspan of 70 inches, although it weighed only two pounds.

The smallest of the microbats is truly small. The "Bumblebee Bat" of Southern Thailand has a wingspan of 6 and 1/3 inches. It weighs between 6 and 7 hundredths of an ounce!

ADAPTATIONS

Bats have a number of special adaptations for flight and for hanging upside down, which makes them unique among mammals. The fingers of the bat are long and slender to support the thin skin of the wings. The fingers are capable of closing together to fold the wing along the forearm when the bat is at rest. The fingers have no nails or claws, but the thumb has a claw-like hook.

The skin of the wing is so thin that newsprint can be read through it, and is so delicate that it can be torn easily. Within this thin skin are blood vessels, which help to cool the bat. Unlike birds, which have hollow bones, bats achieve weight reduction by having thinner bones. The skull of the bat tends to be almost paper-thin.

Bats' legs are quite small and are generally not used for movement. Their legs and their tail expand the tail membrane and are used for hanging upside down from a ceiling or wall. By hanging upside down, the bat's weight is transferred from the thin leg bone to body muscles and tendons. There are five toes, each with a sharp claw that allows the bat to suspend itself from the ceiling. The toes are turned backward, and are curved, allowing the bat to hang from the slightest rough area.

The flatness of a bat's chest has advantages, particularly in entering small cracks. Scientists believe that from the beginning of their evolution bats sought out constricted hiding places. Species of bats that fly long distances in open country, instead of zigzagging through woodlands, have more powerful wing strokes produced by larger heavier muscles. Bats with this type of musculature include the Hoary Bat and the Mexican Free-tailed Bat. Most bats living in this area fly at 10-12 miles per hour for short bursts.

FEEDING HABITS

The feeding habits of bats are quite diverse. Types of food range from insects to fish. Some bats actually eat flowers, and others feed only on the nectar of flowers.

Only insect-eating bats live in North America. It is interesting to note that even when all of the bats of a given area feed on insects, the bats are able to avoid competition by dividing the habitat, or feeding time, or by preferring different insects. Red bats, for example, feed high above the treetops, while Tri-Colored Bats (Eastern Pipistrels) feed in the treetops. Although they may feed on the same insects, bats have separated themselves, thus insuring food for each. Gray bats and Tri-Colored Bats each feed on different types of insects.

Bats in the United States primarily eat night flying insects such as moths, beetles, gnats and mosquitoes. It is estimated that bats in Arkansas can consume 150 large insects or 5,000 small ones per hour!

A single Gray bat may eat one-third or more of its 10-gram body weight in insects each night - approximately 3,000 or more insects. This would mean the 250,000 Gray bats hibernating in a Sylamore District Cave would consume approximately 150 billion insects weighing a total of 184 tons each season, during the 200 days per year when they are active.

Indeed bats are an important factor in nature's balance to control insects that would otherwise damage forests and crops, harass wildlife, and make our lives less pleasant.

OZARK BIG-EARED BAT

The range of the Ozark big-eared bat includes only a few caves in northwestern and north-central Arkansas, southwestern Missouri and eastern Oklahoma. Due to the rarity of this species, knowledge of their biology and habits is limited. In Arkansas it is known to use caves and crevices for summer and winter habitat. They hibernate in tight clusters of a few to a hundred or more individuals in areas with temperature ranges of 39-49 degrees. Maternity colonies are located in small, relatively warm caves with temperatures around 60 degrees. These bats tend to emerge from caves on a later feeding cycle than most other Arkansas bats, leaving usually well after dark. Moths appear to be a major component of their diet along with other small insects. No long distance migrations have been reported for this species, and the major Arkansas colony only moves about 5 miles between hibernaculum and maternity caves. Like many other bats, this species returns year after year to the same roost sites.

GRAY BAT

The range of the Gray bat includes cave regions of Arkansas, Missouri, Kentucky, Tennessee and Alabama with occasional colonies in adjacent states. Although the Gray bat population exceeds one million, 95% may hibernate in only eight known caves. One of these cave sites is located on the Ozark National Forest in Arkansas and may house approximately 15% of the total Gray bat hibernating population. They hibernate in tight clusters up to several hundred thousand individuals in areas with temperature ranges of 42-52 degrees. Maternity colonies are located in large, relatively warm caves with temperatures of 58-77 degrees. Because of their highly specific requirements, fewer than 5% of the available caves are suitable for occupation by Gray bats. Male Gray bats, along with nonreproductive females, form summer bachelor colonies. Blanchard Springs Caverns on the Ozark National Forest houses a summer bachelor colony of more than 20,000 individuals. Gray bats feed primarily over water along rivers, streams and lakes foraging within 15 feet of the surface. Mayflies are a major component in the diet, but they will feed on other insect species as well.

INDIANA BAT

The range of the Indiana bat includes cave regions of Arkansas, Oklahoma, Iowa, and east to Vermont then south to northwestern Florida. Although the Indiana bat population exists at about 500,000, 85% may hibernate in only six known locations. The largest known number hibernating in an Arkansas cave is about 2,000 and less than 3,000 are currently known to hibernate in the entire state. Very few of these bats have been recorded form Arkansas during the summer. They hibernate in large, dense clusters of up to several thousand individuals in areas with temperature ranges of 46-52 degrees. They can frequently be found at 300 bats per square foot. Attempts to locate summer colonies in Arkansas, by netting at several locations in various habitats, resulted in failure to capture female bats. It is likely that female Indiana bats from Arkansas caves migrate north to maternity roost sites north of the Ozark Mountains. Indiana bats feed primarily over riparian stream corridors from an air space of about 6 feet to 95 feet high near the foliage of streamside and floodplain trees.

HIBERNATION

Insect-eating bats living in the temperate areas must either migrate farther south or hibernate during the winter when their food is not available. Fall migration to find suitable hibernacula may begin as early as July or August in northern climates, and September into October in southern climates. When bats move to their hibernation quarters their body temperature is lowered to that of the surroundings, which must be above freezing. Bats will begin their long winter's sleep using stored fats as their food sources. As a true hibernator, the bat's heart rate and breathing rate also drop to just a few times per minute. In this state, a bat can conserve its store of energy and survive a long winter without feeding. A little brown bat, for example, at the optimum temperature of 36 degrees F., expends only 20 calories a day.

REPRODUCTION AND LONGEVITY

Courtship and mating of hibernating bats occur in the fall when bats are at their nutritional peak. Sperm may then be stored in the female's genital tract over the winter, with fertilization occurring in the spring when food is once again available to support the pregnancy. The gestation period for bats is about 2 months.

By early summer, male and female bats have chosen separate quarters, with males in the cooler locations. Generally bats bear only one young at a time although some species bear twins, or sometimes even triplets. In the U.S., baby bats are usually born in May or June when night-flying insects are plentiful. Young bats remain with the mother until they are sexually mature, often for one or two years.

Infant mortality is high among bats. Babies may die from falls, disease, predation, or parasites. Adults, however, have relatively long lives with an average lifespan of 10 years. There are several records of bats over 20 years of age.

ECHOLOCATION

The process of sending out sound and listening for echoes is termed "echolocation". A bat can fly in total darkness with little fear of collision. All microbats depend on echolocation for tracking insects or other prey, and for avoiding obstacles. Because of this specialization, these bats often have large mobile ears for receiving directional sound. The tragus, the thin fleshy projection in front of the ear opening, is thought to act like a tuning fork to aid in carrying sound down to the middle ear.

The echo a bat hears result from sounds made by its voice at frequencies often too high to be audible by humans. These sounds are emitted at varying pulse rates up to 50 or more times per second. The pitch and frequency can be varied depending on the needs of the bat. For example, a bat will give a low pulse rate of longer bursts of sound at a high frequency for locating an insect. Then the pulse rate increases, the pulse length shortens, and the pitch is lowered to provide more precise guidance until the insect is caught.

Although other animals can, and do, use echolocation, bats have probably perfected it to its best usage. Man, with all of his intelligence and specialized electronic equipment, is unable to duplicate the efficiency of the sonar of bats. Our elaborate sonar gear weighs many hundreds of pounds; that of the bat weighs no more than a single gram (1/28 of an ounce)!

DISEASE

Rabies: Rabies is a virus that attacks the central nervous system and may be carried by any mammal. In the United States, rabies is most frequently reported in skunks, foxes, cattle, and dogs. Bats seem to be the only mammals that can contract this disease and survive. Estimates are that probably 15-20% of all bats in Arkansas may carry rabies. Humans can contract rabies by receiving a bite or scratch from an infected animal, or by eating or handling infected tissue if there is an opening on the skin or digestive tract. Whenever an animal bites someone, the brain tissue of the animal can be examined to determine whether it was rabid. If the disease is untreated it is often fatal.

Histoplasmosis: This disease is caused by a mold, Histoplasma capsulatum, which lives in soil enriched by bird or bat droppings. Histoplasmosis can be contracted by inhaling dust containing the microscopic spores. Generally the infection is minor with symptoms similar to the flu. In 1965, 24 samples were collected from guano taken from Blanchard Springs Caverns, and all were free of the fungus. However, there is a possibility of its existence in Blanchard.

CONSERVATION AND PRESERVATION

Bat populations have been declining at an alarming rate in the U.S. during the past 20 years. Disturbances by man have affected many cave populations, since many bats are rather sensitive to intrusion, and will leave a preferred site after repeated molestation. Disturbances during hibernation are especially damaging since the process of waking up utilizes a great deal of the bat's precious energy store. If a sufficient amount of energy is expended, the bat will emerge from hibernation before there is any food to eat and will starve to death. The bat populations that are most threatened are those that hibernate in large colonies with hundreds of thousands of other bats.

Insecticides and pesticides carelessly used by man have probably been factors in recent reports of massive deaths in bat colonies in the Southwestern United States and Mexico.

The collection of bats by irresponsible people for various scientific research projects has decimated several bat colonies during recent years. With their low rate of reproduction, bats cannot withstand heavy cropping and still maintain their population.

If bats are to remain a conspicuous part of our fauna, we must initiate conservative measures. The only way future generations will realize the magnificent beauty and grace of these remarkable flying mammals is for all of us to protect suitable habitat, such as caves, minimize disturbance of present bat colonies, and discontinue the use of harmful residual pesticides.

The bats would really appreciate your help!

BATS USING BLANCHARD SPRINGS CAVERNS AND OZARK-ST. FRANCIS NATIONAL FOREST HABITATS

Gray Bat - *Myotis grisecens* - Endangered - Lives in caves for roosting and bearing young.
Habits: Colonial.
Weight: 1/4 to 1/3 ounce.

Keen Bat - *Myotis keeni* - Lives in mine tunnels, caves, hollow trees, forested areas.
Habits: Occurs in small colonies, known to live 18-1/2 years in the wild.
Weight: 1-4 to 1-3 ounce.

Tricolored Bat (formerly known as the Eastern Pipistrel Bat) - *Perimyotis subflavus* - Lives in caves, rock crevices, buildings.
Habits: Solitary except during mating season. Smallest bat in U.S.
Weight: 1-5 to 1/6 ounce.

Indiana Bat - *Myotis sodalis* - Endangered - Winters in caves and man-made structures; summers in hollow trees.
Habits: Colonial in winter, scattered in summer.
Weight: 1-4 to 1/3 ounce.

Big Brown Bat - *Eptesicus fuscus* - Winters in caves and man-made dwellings; summers in trees and outbuildings.
Weight: 1/3 ounce.

Blanchard Springs Caverns Kriss Kross

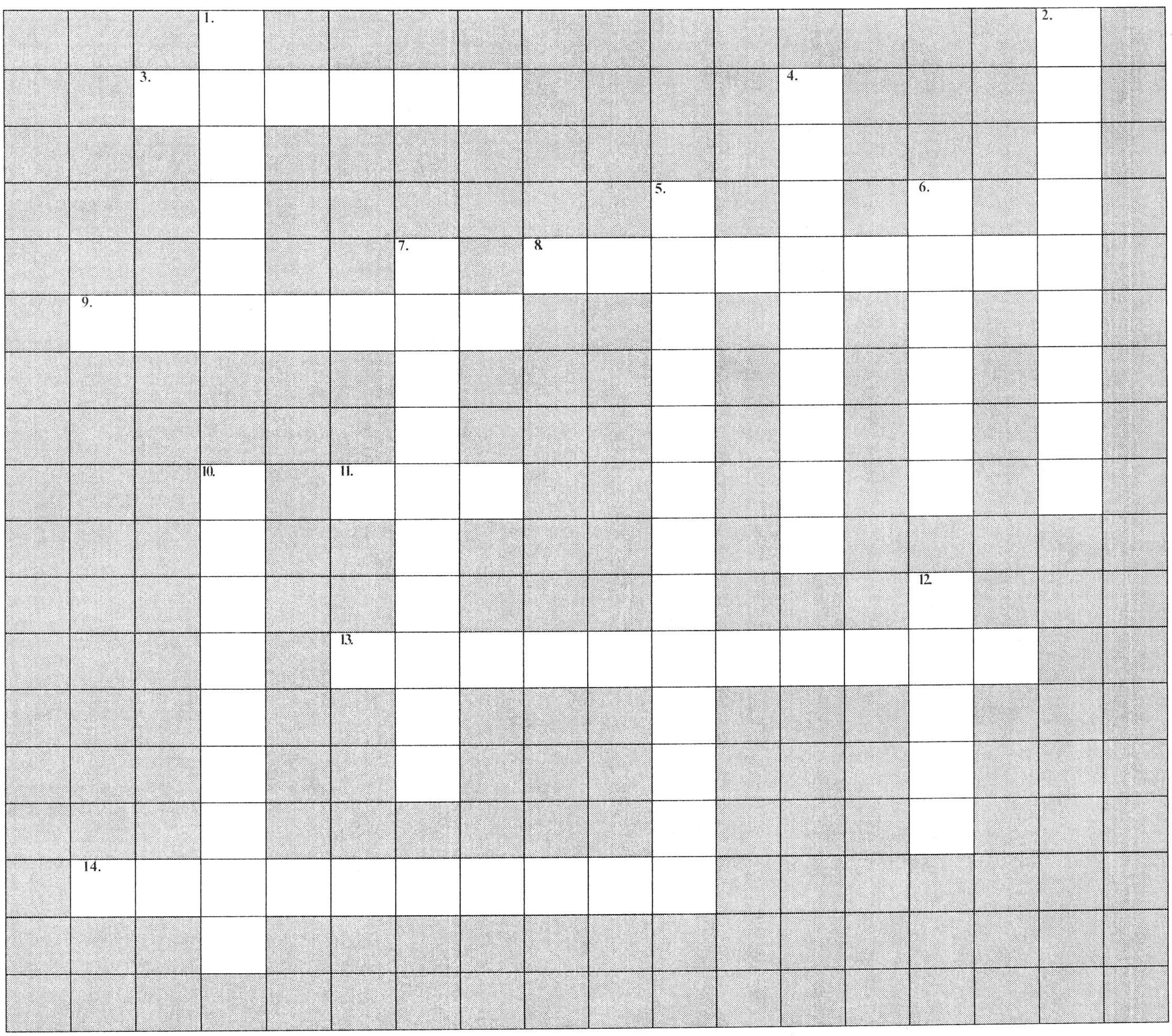
Complete the puzzle using the clues.

Down

1. An impression of an animal left behind in the rock
2. A formation formed from deposits of calcite left on cave walls by sheets of moving water
4. A stone made of shells and other organic matter that were compressed into layers
5. Makes rainwater acidic as it falls to the ground (2 words)
6. A cave which is still receiving water
7. A formation attached to the ceiling of the cave
10. A hollow formation attached to the ceiling of the cave (2 words)
12. The creating factor of the hills, valleys, caves and speleothems found in the Ozarks

Across

3. A formation that reaches from the floor to the ceiling of a cave
8. A calcite formation formed on a concave wall and that can have folds like a curtain
9. Formed from dissolved limestone
11. The only flying mammal
13. Formed when slow-moving water flows along the cave floor, bumping across rocks (2 words)
14. A formation made from dripping water, and attached to the floor of the cave



Blanchard Springs Caverns Kriss Kross Answers

Complete the puzzle using the clues.

Down

1. An impression of an animal left behind in the rock

2. A formation formed from deposits of calcite left on cave walls by sheets of moving water
4. A stone made of shells and other organic matter that were compressed into layers
5. Makes rainwater acidic as it falls to the ground (2 words)
6. A cave which is still receiving water

7. A formation attached to the ceiling of the cave

10. A hollow formation attached to the ceiling of the cave (2 words)
12. The creating factor of the hills, valleys, caves and speleothems found in the Ozarks

Across

3. A formation that reaches from the floor to the ceiling of a cave
8. A calcite formation formed on a concave wall and that can have folds like a curtain
9. Formed from dissolved limestone

11. The only flying mammal

13. Formed when slow-moving water flows along the cave floor, bumping across rocks (2 words)
14. A formation made from dripping water, and attached to the floor of the cave

ESS.8.4.7, ESS.9.4.1, ESS.8.5.1, ESS.8.5.2, ESS.8.5.3, ESS.8.5.4, ESS.8.5.5, ESS.8.7.8, ESS.8.7.14, ESS.8.7.16, ESS.8.7.17, ESS.9.5.1, ESS.9.5.2, ESS.9.5.3; LS.3.6.3, PS.5.7.8

			1. F													2. F	
		3. C	O	L	U	M	N					4. L				L	
			S									I				O	
			S							5. C		M		6. L		W	
			I			7. S		8. D	R	A	P	E	R	I	E	S	
	9. C	A	L	C	I	T	E			R		S		V		T	
						A				B		T		I		O	
						L				O		O		N		N	
			10. S		11. B	A	T			N		N		G		E	
			O			C				D		E					
			D			T				I				12. W			
			A		13. R	I	M	S	T	O	N	E	D	A	M		
			S			T				X				T			
			T			E				I				E			
			R							D				R			
	14. S	T	A	L	A	G	M	I	T	E							
			W														

GEOLOGY OF BLANCHARD SPRINGS CAVERNS

The Rock: Blanchard Springs Caverns is located in sedimentary rock that was laid down during the Upper Ordovician - Lower Mississippian periods (310-460 million years ago). At that time northern Arkansas was covered by a shallow sea that teemed with life. During most of the period limey sediments built up from the shells of the sea animals that died. As the layers of shells got deeper and deeper, they were compressed to form limestone rock.

Periodically, there was also deposition of layers of mud and sand. These layers became shale and sandstone.

The Uplift: Lower Pennsylvanian (about 310-350 million years ago). Enormous forces in the earth's crust began a gradual uplifting of the large, oval-shaped landmass that became known as the Ozark dome. During the uplifting, which was so slow that if we were living here we would not have known it was going on, layers of rock often cracked or fractured under the stress. Imagine a multi-layered cake. Now think what would happen if you started pushing the cake up in the center.

Erosion: As the land raised, the surface streams flowed over the land in the weakest places producing deep valleys, sheer bluffs, and the rugged topography as we know it in the Ozarks.

Creation of the Cave: (50-70 million years ago). As the surface eroded, so did cavities underground, though by a different process. Some of the rainwater percolated down through the cracks in the rock layers. As the water passed through the soil, it picked up CO_2 (produced during the decomposition of organic material) to add to the CO_2 picked up in the air. This formed a mild acid called carbonic acid, giving the water greater dissolving power. (A carbonated soft drink contains carbonic acid.) As the acid water came in contact with the limestone, the limestone ($CaCO_3$) chemically reacted with the carbonic acid. In this way solutioning occurred along the fractures. Very slowly, over long periods of time, crevices became channels; channels enlarged into tunnels; tunnels joined together to form rooms, water filling the whole carved out area.

Blanchard Springs Caverns is a cavity formed primarily in layers of limestone with thin layers of shale and sandstone which collapsed. The cavern cavity zone lies between Boone Formations, which are mostly bedded chert, an insoluble siliceous rock, and St. Peter Sandstone, which is also insoluble.

Decoration of the Cave: (The oldest formations are approximately 2-5 million years old.) As the surface streams carved deeper into the hillsides, the water table gradually dropped. Springs, where water emerges from the hillsides, give the cave water an outlet. Finally the water table dropped below the level of the cave, leaving the cave air-filled and ready for decoration. Remember this is still occurring very slowly, and over long periods of time. Because Blanchard Springs Caverns still has water entering and flowing through it, it is considered a "living" or "active" cave. The following processes are ongoing:

- Deposition of Clay: The insoluable residue of dissolved limestone is fine-grained clay called "terra rosa" (meaning red earth). After the springs created a drain for the cave water, the underground stream began to flow and the clay eroded or moved from place to place. It was the presence of clay near the ceiling in the Discovery Room that gave Hugh Shell and Hail Bryant the clue that there was an upper level to Blanchard Springs Caverns.

- Breakdown: The large piles of rock sometimes covering the cave floor probably fell as the water level in the cave dropped and no longer helped support the ceiling. The ceiling collapse continued until the ceiling achieved a stable arch where the cavern wall helped hold up the ceiling. (Think about playing building blocks and building stairsteps up one side and down the other. Each preceding block supports the next one.) It is safe to guess that over the past eons Blanchard Springs Caverns has achieved a stable ceiling. Where the trail goes, the ceiling has been tested and is monitored to insure safety.

- Deposition of Speleothems: A speleothem (speliaon - cave, therma - deposit) is a "secondary mineral deposit formed in caves." In other words a speleothem is formed from a mineral dissolved out of the bedrock and deposited in the cave. The vast majority of speleothems in Blanchard Springs Caverns are made of calcite, a crystalline mineral of calcium carbonate ($CaCO_3$). The $CaCO_3$ is dissolved from the limestone bedrock by the weak carbonic acid solution resulting from rainwater percolating down through the rock. When the solution enters an air-filled passage the CO_2 is released due to the difference in CO_2 concentration between ground water and cave air. (The CO_2 content in the cave air is 25-250 times lower than the CO_2 content in ground water.) The loss of CO_2 can cause calcite deposition. The tremendous variety of speleothems is due to the number of paths the water may take when it enters the cave by dripping through the ceiling, running down the walls, splashing on the cave floor, or oozing through the walls. Some of the variables that alter the size and shape of the speleothems are:
  - Rate of dripping;
  - Size and shape of the opening by which water enters the cave;
  - Varying volume of water entering the cave;
  - Changing route of water through the overlying rock;
  - Air currents in the caverns;
  - Slope of the surface over which the water is flowing;
  - Variations in the concentration of $CaCO_3$;
  - Variations in the amount of carbonic acid.

  Can you think of others?

- Resolutioning: Since the surface is ever changing, animals and plants are living and dying and the water may change its course as it passes through the rock, the ratio of $CaCO_3$ carried in the water to the amount of acidity is variable. When the incoming solution is under saturated with calcite, resolutioning will take place. In other words, the calcite that has been deposited to form speleothems will be taken back into the solution and will be washed away. Speleothems that are dry and look dull and chalky (like they are covered by dried toothpaste) are good examples of resolutioning in the Coral Room.

- Dormancy: There are some dry speleothems in Blanchard Springs Caverns which attest to the changing course of the water. These formations are considered dormant, not just dead, because water may return one day. Our viewing of the cave is just a tiny glimpse of its life. It's like seeing one frame of a long playing movie - one frozen instant. The cave has constantly been changing in the past and it will continue to do so in the future.

<u>Coloring of Speleothems</u>: Pure calcite is a milky, translucent white. However, pure white speleothems are rare. Most speleothems are stained by impurities carried into the cave with water and deposited between the crystals of calcite. Iron impurities typically stain speleothems yellow, brown, or orange. Black, blue-gray, and pastel blue colors are probably due to manganese compounds. A sample of dark stains on the cave ceiling over the loop in the Coral Room was found to be manganese dioxide. However, a sample of blue-gray flowstone tested by a spectrophotometer contained only calcium, sodium and iron. Cave micro-organisms and organic materials also probably contribute to

the colors found in a cave, especially black, brown and red. The stain of color is concentrated on the outer layers of the speleothem. As the speleothem grows, the crystal bonding structure of the calcite forces the color to these outer layers.

'n the very distant future: What remains for Blanchard Springs Caverns is for the surface erosion to wear the cavern ceiling thinner and thinner. Eventually, hundreds of thousands of years in the future, the cavern ceiling will collapse as a huge sinkhole. The sediment will wash in to fill the sinkhole and may obliterate all signs of the cavern system. Meanwhile more passages may be actively forming and enlarging underground and new caves may be given entrances.

References:

Ford, T.O. & C.H.D. Allingford, The Science of Speleology, Academic Press, 1976.

Hill, Carol A., Cave Minerals, National Speleological Society, Huntsville, AL, 1976.

Moore, George W. & G. Nicholas Sullivan, Speleology, The Study of Caves, Zephyrs Press, Inc., Teaneck, NJ, 1978.

"The Amazing World Below" movie.

"Welcome to Blanchard Springs Caverns" brochure.

/ertical file at Blanchard:

Cohoon, Richard R. "Blanchard Springs Caverns, Tour A - A Geological Report Concerning the Features of the Cave Significant enough for Public Interpretation'" 1968.

Tony V. Field, "Geological History of Blanchard Springs Caverns," (Geology - BSC).

GEOLOGY

Among numerous inquiries received by the U.S. Geological Survey are those concerning the age of the earth, division of geologic time, and how the earth's rocks, meteorites, and moon specimens are dated. The following is based on information contained in a booklet, "Geologic Time," one of a series of non-technical publications prepared by the USGS to answer inquiries about a variety of the earth science subjects.

Questions and answers about geologic time:

How old is the earth? The earth is at least 4.6 billion years old, according to recent estimates. A great ɔart of the evidence for this age is contained in the earth's rocks.

What scales are used to tell geologic time? Two scales are used to date the various earth-shaping episodes - a relative time scale, based on the sequence of layering of the rocks and the slow but progressive development of life as displayed by fossils preserved in the rocks; and an atomic time scale, based on the natural radioactivity of chemical elements in the rocks.

What are some early geologic speculations? In the 5th century, B.C., the historian Herodotus made one of the earliest recorded geological observations. He found fossil shells far inland in what are now parts of Egypt and Libya and correctly inferred that the Mediterranean Sea had once extended much farther south. In the 3rd century B.C., Erathosthenes depicted a spherical earth and even calculated its diameter and circumference. However, less than 500 years ago, sailors aboard the Santa Maria begged Columbus to turn back lest they sail off the earth's "edge." Most people appear to have traditionally believed the earth to be quite young - that its age might be measured in terms of thousands of years, but certainly not in millions or billions.

When were fossils linked to geologic time? Around 1800, William "Strata" Smith, an English civil engineer and surveyor, had a hobby of collecting and cataloging fossil shells from areas in southern England where "limestones and shales are layered like slices of bread and butter." His hobby led to the discovery that certain layers contained fossils unlike those in other layers. Using these key or index fossils as markers, Smith could identify a particular slow but progressive development of life; therefore, scientists use them to identify rocks of the same age throughout the world.

What are the major divisions of geologic time? Such recurring events as mountain building and sea encroachment, of which rocks themselves are records, mark units of relative geologic time, even though actual dates of the events are unknown. By comparison, the history of mankind is similarly organized into relative units of time. We speak of human events as occurring either B.C. or A.D. - broad divisions of time. Shorter spans are measured by the dynasties of ancient Egypt or by the reigns of kings and queens in Europe. Similarly, geologic time divides the earth's history into eras - broad spans based on the general character of life that existed during these times, and periods - shorter spans based partly on evidence of major disturbances of the earth's crust. Following are the geologic eras, ranging successively from the present to the oldest:

- Cenozoic (from the present to about 70 million years ago);
- Mesozoic (from about 70 million to 225 million years ago);
- Paleozoic (from 225-500 million years ago); and
- Precambrian (600 million years ago and older) marking the time between the birth of the planet and the appearance of complex forms of life. More than 80% of the earth's estimated 4.6 billion years fall within this Precambrian Era.

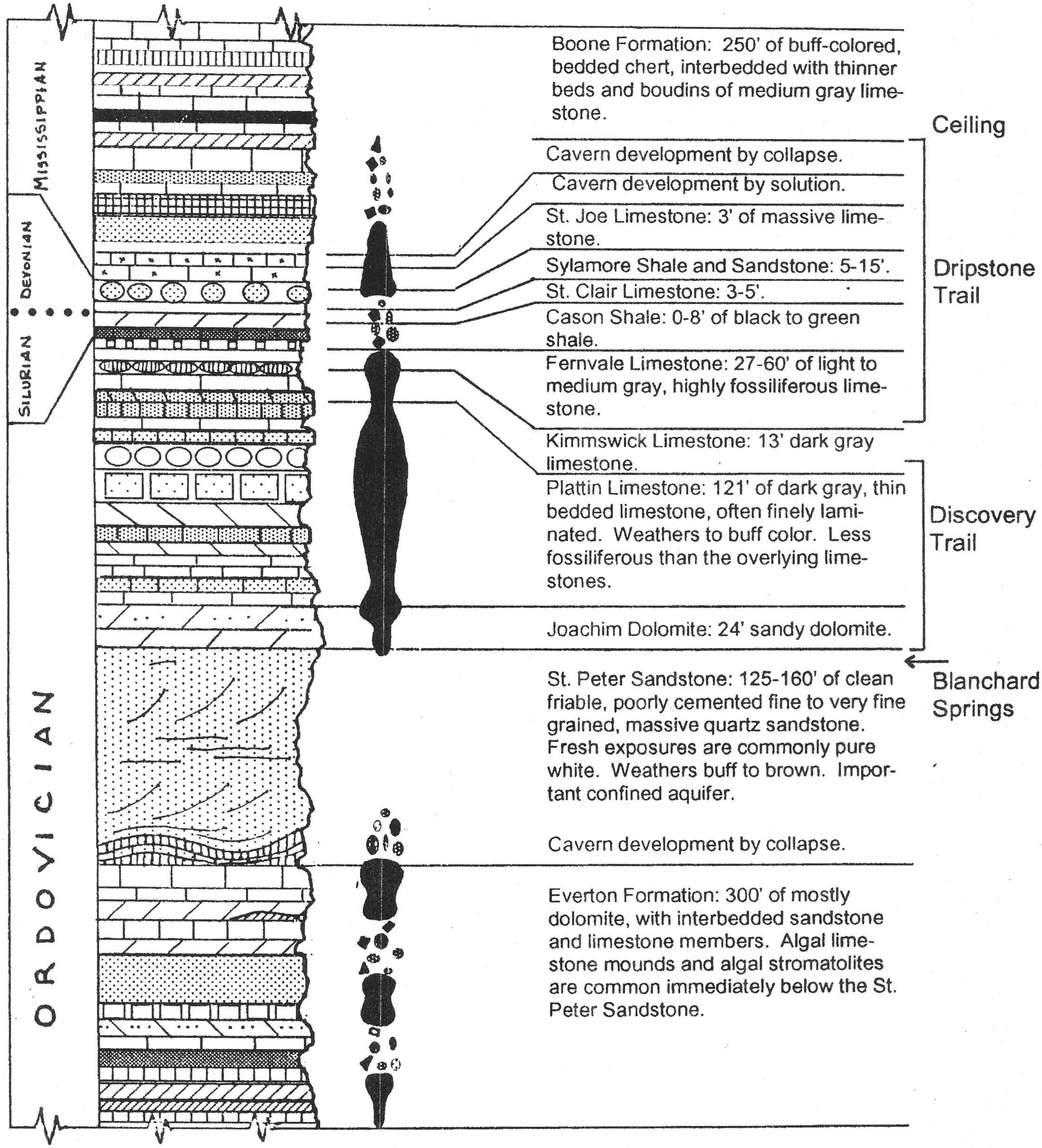
What is Radioactive Decay? Atoms of the same element with differing atomic weights are called isotopes. Radioactive decay is a spontaneous process in which an isotope (the parent) loses particles from its nucleus to form an isotope of a new element (the daughter). The rate of decay is conveniently expressed in terms of an isotope's half-life, or the time it takes for one-half the nuclei in a sample to decay. The isotopes of certain elements decay very slowly. Those of potassium-40 have a half-life of 1.3 billion years. The potassium-40 method is one of the most useful dating methods available to the geologist because it can be used on rocks as young as a few thousand years as well as the oldest rocks known.

What is the "Carbon-14" Dating Method? An important atomic "clock" used for dating purposes is based on the radioactive decay of the isotope carbon-14, which has a half-life of 5,730 years. Carbon-14 is being produced continuously in the earth's upper atmosphere as a result of nitrogen-14 isotopes being struck by neutrons that have their origin in cosmic rays. This newly formed radiocarbon becomes mixed with the nonradioactive carbon in the carbon dioxide of the air, eventually finding its way into all living plants and animals. After the death of an organism, the amount of radiocarbon gradually decreases through the radioactive decay as it reverts to nitrogen-14. By measuring the amount of radioactivity remaining in organic materials, the amount of carbon-14 in the materials can be calculated, and the time of death can be determined. Because of the relatively short half-life of carbon-14, the radiocarbon clock can be used for dating events that have taken place only within the past 50,000 years.

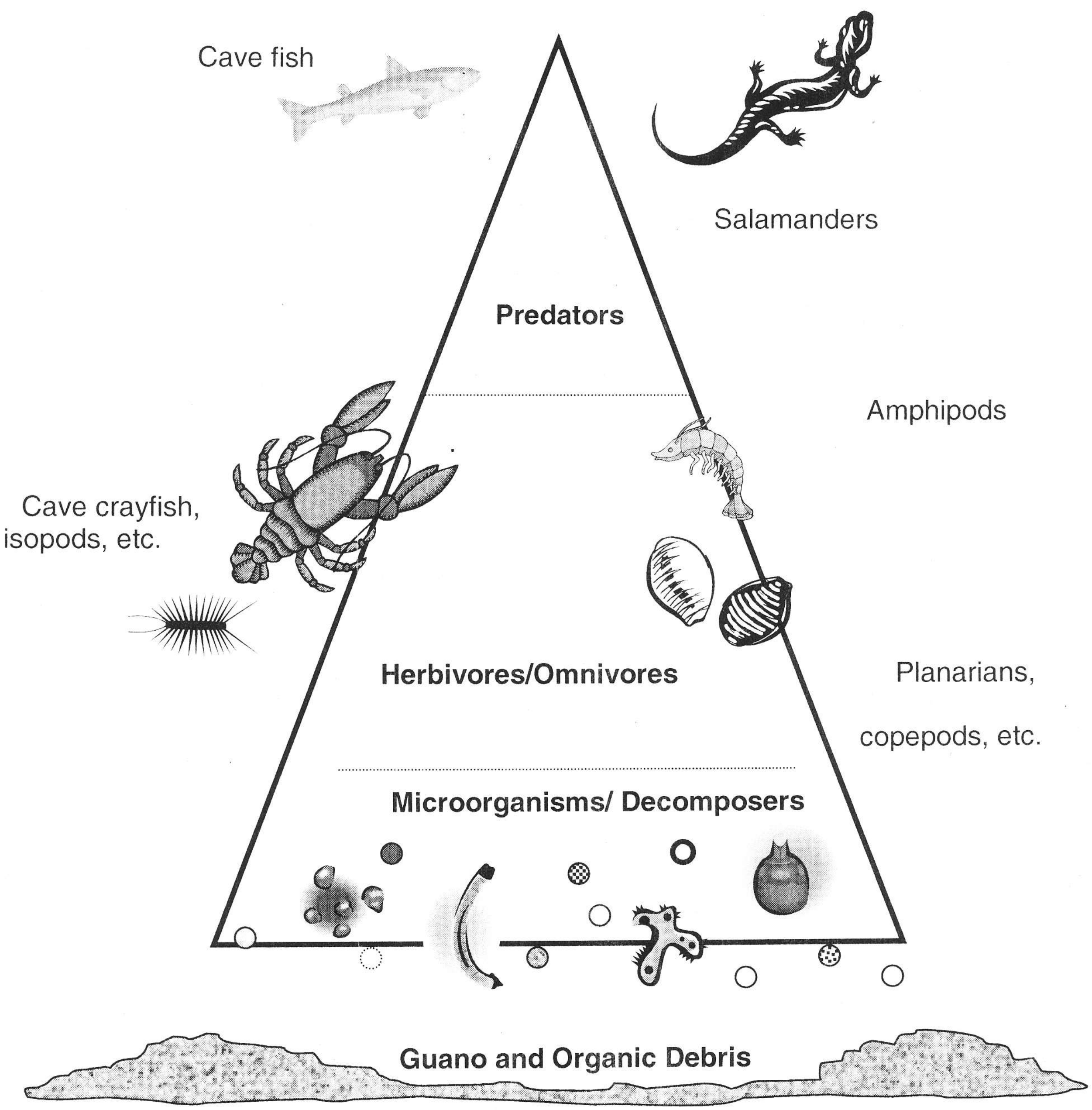
What are some of the oldest dated rocks on earth? Rocks in southwestern Minnesota have been found to be 3.8 billion years old -- the oldest rocks thus far found on earth. The ancient rocks -- a granite-gneiss -- occur along the valley of the Minnesota River and are particularly well exposed near the town of Granite Falls, Minn. The age of the rocks was calculated to be about 3.8 billion years old -- plus or minus 100 million years -- from using the rubidium-strontium and uranium lead dating methods. Rocks of comparable age have been found in western Greenland and other rocks -- 3 to 3.5 billion years old -- are known to occur in southern Africa and in the Soviet Union. Rocks older than 3 billion years probably have survived due to the continuing erosion of the earth's surface, and the "reconstruction" of rocks deep within the earth.

How old are meteorites? An approximate age for the earth has been determined from studies of meteorites -- matter from space. Stony meteorites contain sufficient uranium to produce appreciable quantities of radiogenic lead, which can be used to measure their ages. Calculations yield an age of about 4.6 billion years for these meteorites. Since the earth and meteorites likely have a similar origin, it seems reasonable to assume that the age of the earth is about the same age as the meteorites.

Generalized Geologic Column for the Sylamore District
Ozark St. Francis National Forests, Arkansas

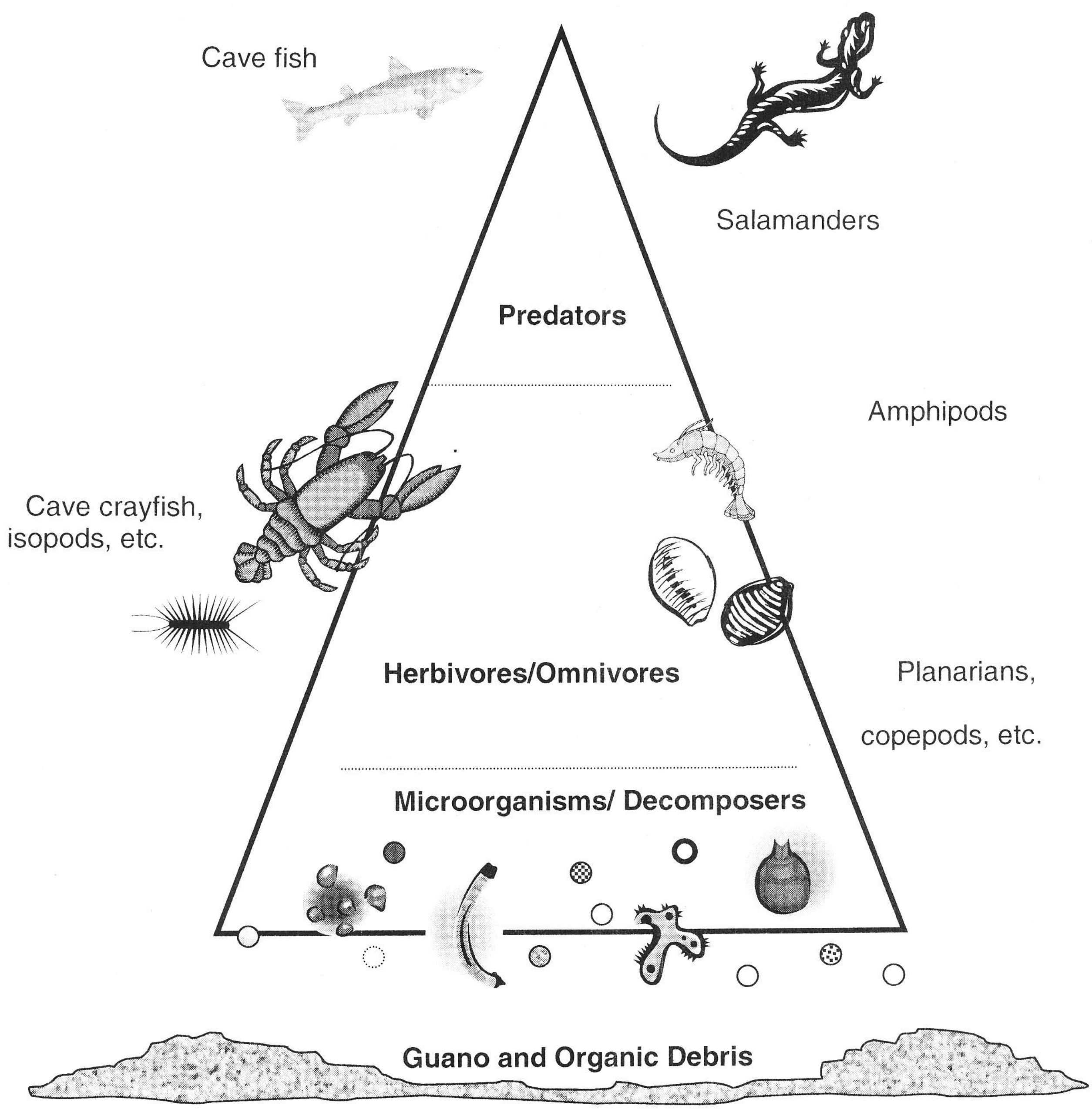


Cave Food Pyramid



In a cave food pyramid, there are few sources of food. Due to the absence of sunlight, the main energy sources are guano and organic debris. This energy input is only a tiny fraction of what the surface receives from the sun. But like any food pyramid, 10% of the available energy is able to transfer from one level to the next. Consequently, the number and variety of organisms in a cave are very small. Since food is so limited, cave life tends to be generalized in their feeding habits. They take advantage of what food is available. For example, even predators may feed directly on the organic debris, thus bypassing two levels of energy loss.

Cave Food Pyramid Teacher's Page

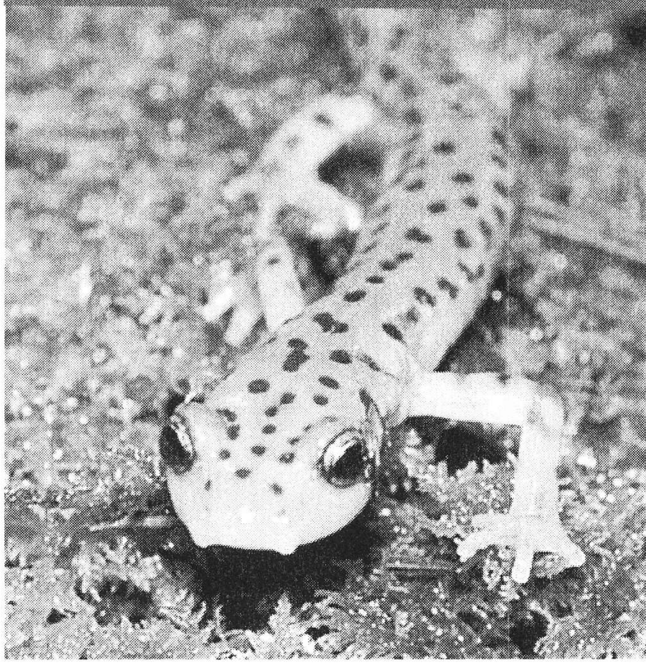


In a cave food pyramid, there are few sources of food. Due to the absence of sunlight, the main energy sources are guano and organic debris. This energy input is only a tiny fraction of what the surface receives from the sun. But like any food pyramid, 10% of the available energy is able to transfer from one level to the next. Consequently, the number and variety of organisms in a cave are very small. Since food is so limited, cave life tends to be generalized in their feeding habits. They take advantage of what food is available. For example, even predators may feed directly on the organic debris, thus bypassing two levels of energy loss.

Arkansas Frameworks: LS.3.8.16, LS.4.4.2, LS.4.5.3, LS.4.5.4, LS.4.5.5, LS.4.5.14, LS.4.5.15, LS.4.6.1, LS.4.6.2, LS.4.8.1

Blanchard Springs Caverns

Cave Salamander



(*Eurycea lucifuga*)

Cave Salamanders are orange to red with distinct blackish spots that cover most of the dorsal surface of the head, body, and tail. They are about 7 inches long and have slender bodies that are shorter than their tails.

Cave Salamanders are found in limestone and sandstone caves, usually in the twilight zone. Prey items consist of invertebrates such as insects, spiders, isopods, mites, earthworms, and snails.

Eggs are deposited during the autumn on the undersides of rocks or on the sides of rimstone pools. Eggs hatch in November and larvae transform in 12 to 18 months.

In Arkansas, they have been reported from Pocahontas, Greenbrier, Monroe, Summers, Mercer, and Fayette counties.

Photo printed with permission from Marshall University from http://www.marshall.edu/herp/Salamanders/cave.htm on 6-23-09

Blanchard Springs Caverns

Changing Groundwater Levels

Objectives:

Students will:

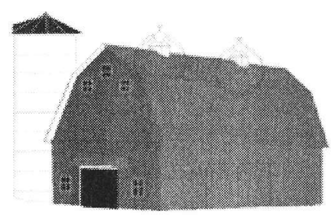
- investigate changing groundwater levels and why they change.
- offer suggestions to keep groundwater levels from rapid decline.
- determine how different rock layers affect groundwater levels.

Arkansas Frameworks: ESS.8.41, ESS.8.4.6, ESS.8.4.7, ESS.8.7.8, ESS.8.7.14, ESS.8.7.16, ESS.8.7.17

Materials:

> **Note:** If you did "Getting the Groundwater Picture", you should already have this setup ready.

- Soda bottle with the ends cut off (used in "Getting the Groundwater Picture")
- glass or cup
- Cup of sand
- Cup of gravel
- Cup of water
- Pump (like a hand lotion pump)
- A piece of cheesecloth or pantyhose



Procedure:

1. Review the activity "Getting the Groundwater Picture".
2. Discuss wells with the students and have them predict what will happen to their aquifer when they begin to use the pump on their well to draw water from the ground.
3. Put a small piece of pantyhose on the bottom of the pump tube so it does not suck in soil or sand. Tape the pump to the side of the bottle so the pump is above and pointing out of the cut end of the bottle. Fill the soda bottle one-half full of small gravel and pour sand on top of that.
4. Have a student fill the bottle about half full of water. Have the students locate the top of the aquifer or water table.
5. Have a student begin pumping water from the aquifer into a glass. At certain intervals, have the students locate the top of the water table. Note the changes. Discuss the reasons.
6. How does the water get back into the well after it has been pumped up? (rain, snowmelt, surface water returning to the soil, water can seep in from other aquifers, etc.) Discuss recharge.

7. Have the students discuss how different substrata would affect the pump. Would it ever bring up mucky water? Would certain rock types mean you would have to put the pump deeper to get water? Would it be easier to get water from shale or limestone? What if the well were to go through a cave?
8. Imagine you are in a farming community. Will irrigation have an affect on your well? What about use of fertilizers or pesticides? Will you always be able to get water at the depth you first drilled to? Would a drought effect your water supply? How would the balance in the water table be maintained? Will other wells from the surrounding area (farms or cities) impact your water supply?
9. Consider the following: Will affects of local industrial practices affect your water quality? What about dumping oil into the ground, dumping chemicals into nearby rivers? What effect would dumping waste directly into old wells?
10. Discuss that the water table is not level, so all wells will not be at the same depth even if they are close to each other. The water table will mimic the surface above, having hills and valleys. Water can dip where the land above does, or it can dip where a well has been pumping water out. In the experiment with the pump, as water was pumped out, the water level dropped. Water drops more rapidly near the well than away from it. Often the replacement water cannot return as quickly as water is being taken out. Most rainfall is evaporated or used by plants, some goes into rivers or streams and only about 1% of water returns to the water table directly.
11. What are some of the problems with getting water from a well? What is the cost of installing a well? (Depth of water, hard rock to break through to get it, cost, chance of well drying if not deep enough, etc).
12. Does the placement of the well matter? Have the students guess, thinking of their own homes, how far a well should be from the following: septic tank, livestock yards, silos, septic leach fields, petroleum tanks, manure storage, pesticide and fertilizer storage and handling. Soil is a filter, but it can only clean so much. After the students have made their guesses, tell them a well should be at least 25 feet from a septic tank; 50 feet from a livestock yard, silos, and septic leach fields; 100 feet from petroleum tanks, manure storage, pesticide and fertilizer storage, and handling; 250 feet from manure piles. If a well is not carefully placed or is misused, anything from the surface can get directly into the water supply without ever passing through the ground.
13. If two wells were placed close together, could this cause a problem? What if one of the wells was contaminated? What if one well connected two aquifers could there be positive effects? How about negative effects? (Wells generally have casings, like a straw around your pump tube, which would not allow water from another aquifer travel down the hole for your pump and pollute the new well or aquifer. However if these casings don't go down far enough, polluted water can enter your new aquifer. State laws vary on how deep these casings have to be. What if the length the law requires is not far enough to protect your well?) Considering all of these factors, how would you decide where is the best place to put your well?

Printed with permission from Wind Cave National Park from
http://www.nps.gov/archive/wica/Hydrology_Groundwater_Water_Race.htm on 6-23-09

Blanchard Springs Caverns

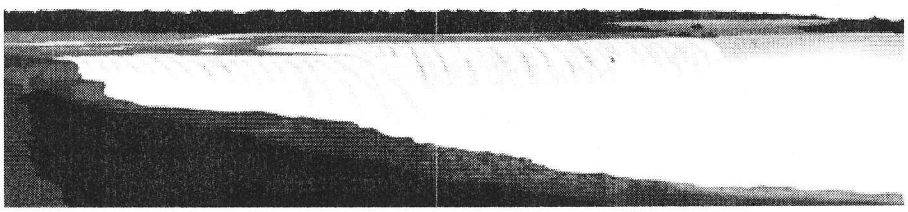
Common Water

Objectives:

Students will:

- illustrate how multiple users of water resources can affect water quality and quantity.
- examine the complexities of providing water for all water users.

Arkansas Frameworks: ESS.8.4.1, ESS.8.4.6, ESS.8.4.7, ESS.8.7.8, ESS.8.7.14, ESS.8.7.16, ESS.8.7.17



Materials:

- The Yellow Pages of a phone book
- One container for each student (bowls or milk cartons with the tops cut off)
- 17 large household sponges: 3 cut into fourths, 5 into thirds, 5 into halves, and 4 whole. (Increase or decrease the number of sponges to fit number of students)
- Various colors of food coloring: put several drops of coloring on all sponges and sponge pieces.
- 5 gallon bucket
- Stopwatch
- Nametags (created by students or gotten from Water Works)

Procedure:

1. Have students list major water user groups in their community and how they use water. The Yellow Pages can be a source of ideas. You can use the cards for the activity, Water Works, for more ideas. Ask students to make a list arranging the water users from those who they think use the most water to those who use the least. This can be done in groups by giving each group different pages from the Yellow Pages to work with.
2. Fill the 5-gallon bucket to the brim with water. Since the water may spill, be sure to conduct the activity outside or in an area that can get wet. You may wish to mark the bucket with a line for every gallon. Tell the students that the bucket represents water stored in an aquifer. Define aquifer, and discuss where the students get their drinking water. The sponges will represent wells pulling water out of the aquifer.
3. Tell the students that they are going to simulate changes in the aquifer over several time periods. Each 30-second round represents a time period (see Round Scenarios below). In

each round, students represent different water users; they should make name tags to identify their roles.

4. For each round, students should position themselves an equal distance from the water source. When the round starts, students fill their sponges with water from the aquifer (bucket). To represent water consumption, have them squeeze water out of the sponges into individual containers. Students can refill their sponges as often as they like during the round.
5. At the end of each round, record how much water remains in the bucket. Tell students to empty half of the water from their containers back into the bucket. This represents used water that makes it back to the aquifer (i.e. when it percolates through the soil, when it is discharged from a factory, after it runs off the surface of a parking lot). Students will notice that the water is colored. Inform them that this represents sewage and runoff from urban and rural areas.
6. Fill the bucket to the brim again by adding clean water before each round.

Round Scenarios:

- It is 100 years ago. A large farm and a small town are located above the aquifer. Distribute sponges cut in fourths to 6 students (town dwellers) and a half sponge to a student representing the farm.
- It is now just after World War II. The size of the town has increased. Many of the town residents are employed in an industry that makes typewriters. The factory is represented by half of a sponge. Two farming areas supply milk and some food (meat, grains, vegetables) for the town; they get one sponge each. Give one sponge to a student who represents a power company. Several community services, such as hospitals, schools, and stores, are now part of the town; each student representing such a service agency gets half a sponge. Provide each family (about 10 students) with a third of a sponge.
- It is the present. The town has continued to grow. A new industry that makes household cleaning products has moved in (another sponge). Represent residential expansion by giving sponge pieces to any remaining students.

Wrap Up:

- Have students discuss the quantity and quality of water at the end of each round.
- Discuss the proportions of sponge pieces distributed to different community members.
- Are water users in their own community represented by the characters in the simulation?
- Do students think the sponge sizes were appropriate?
- Were there any groups that used too much water?
- How could the activity be adjusted to ensure enough clean water for all users?
- Students may suggest making fewer trips to soak their sponges or reducing the size of their sponges.
- Discuss methods of reducing waste discharge (e.g., using organic fertilizers, reducing litter, upgrading sewage treatment plants).
- Encourage the students to find a use for the water that was used in this activity.

Blanchard Springs Caverns

Dripping Crystals

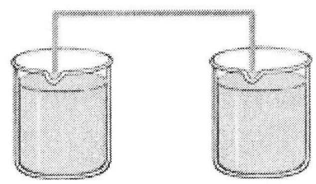
Objectives:

Students will:

- investigate deposition, the process that allows growth of different secondary cave formations.
- recognize that different chemical compounds produce different speleothem types.
- identify several speleothems.

Arkansas Frameworks: ESS.8.5.2, ESS.8.5.3

Materials:



- 3 pieces of yarn or string
- 6 jars or cups of the same size
- 3 saucers
- Epsom salts
- baking soda (sodium bicarbonate)
- washing soda (sodium carbonate)
- warm water
- spoon or coffee stirrer
- several books about caves and speleothems
- internet sites about caves and speleothems - see Internet Sites Related to Caves and Karst (below, or look up on Web at http://www.nps.gov/archive/wica/Hydrology_Cave_&_Karst_Internet_Sites_Related_to_Caves_and_Karst.htm)

Procedure:

1. Tell the students that they will be conducting an experiment that will demonstrate how water can deposit minerals to create cave formations, or "speleothems" (secondary mineral deposits formed in caves).
2. Ask the students if they have ever seen stalactites or stalagmites. Do they know which is which? Stalactites hang tight to the ceiling and stalagmites come up from the ground and might reach the ceiling someday. How do they form? Discuss how water can carry calcite in solution then deposit the calcite in crystalline form in a cave. If necessary use sugar, salt, jello, or kool-aid as examples of minerals disappearing into solution.
3. Explain that the process would take millions of years in a cave. The students will speed up the process in the classroom by using a concentrated solution and sunlight (to aid evaporation).

4. Students may create the set-up, help with it, or watch as you complete the steps. If the students create the set-up have them work in small groups. Procedure: Dissolve as much Epsom salt as you can in **very** warm water. Soak a piece of string (yarn) in the solution. Lay the yarn on the jars so that both ends are well inside the solution in each jar and the middle is over the saucer with a slight dip in the middle. (The yarn has to be saturated and needs to dip below the water levels in the cups to create osmosis pull on the water.)
5. At the same time, set up the second set of jars using baking soda instead of Epsom salt.
6. Set up a third set of jars, using washing soda. Leave the jars for several days.
7. The solution in the jars will drip onto the saucer, creating a stalactite and stalagmite, and eventually a "column" (when they grow together) or popcorn. Hopefully this will occur... it doesn't happen every time. However, within 48 hours, the students will notice that the crystals look very different in comparison. The baking soda will form delicate "popcorn" formations along the string, the washing soda and Epsom salts should create stalactites.
8. As the students check their experiment each day, discuss the differences between the baking soda and Epsom salt deposits. Why are they different?
9. Discuss what happens when carbonic acid degasses, as it drips or seeps out of a cave wall. Degassing is the process where the acid can no longer hold anything in solution and must deposit it. Why does this cause deposition of calcite?
10. Do you notice crystals in other places than at the dip in the string? Where and why?
11. What property of water allows the string to stay wet and drip water? (Osmosis)
12. Give the students time during class to look at the included reference materials. Have them familiarize themselves with the following formations: stalactite, stalagmite, soda straw, column, popcorn, frostwork, boxwork, and flowstone.
13. Watch the water level in the glasses and discuss formations (speleothems), water levels, groundwater, and recharge. Notice the water level goes down and does not get refilled. Much of the water is being pulled into the yarn and drips onto the saucer. Would this happen in a cave situation? (Yes, the water would drip and go further into the ground.) If there is no recharge, what will eventually happen? What would this mean to the cave system?

Hints:

Be careful with the Epsom salts. The crystals are very delicate. You will need to add quite a lot and make sure they are dissolved in solution. It will be several days before they crystallize on the string, but they should. If the formation gets heavy, it will break off. Watch the crystallization below the drip, it can be rather interesting! To make this work, a siphon must be made. The yarn needs to be saturated and the place that is dripping needs to be lower than the end of the yarn in the cups.

Internet Sites Related to Caves & Karst

Introduction to Caving... A MUST USE SITE!

www.goodearthgraphics.com/virtcave/

Karst Hydrology:

www.dyetracing.com/karst/ka01000.html
Karst Hydrology Information

www.umsl.edu/~joellaws/ozark_caving/mss/karst.htm
Karst Definitions and Information

http://karst.wku.edu
Center for Cave & Karst Studies (Western Kentucky University)

www.karstwaters.org
Karst Waters Institute

http://ga.water.usgs.gov/edu/index.html
USGS Water Science for Schools

www.dyetracing.com/dyetracing/dyetrace.html
Dye Tracing Information

www.howecaverns.com/cavecon.htm
Cave and Karst Conservation

Sinkholes:

http://www.caves.org/conservancy/ikc/slide_7.htm
Sinkholes

http://www.state.va.us/~dcr/dnh/lws.htm
Great sinkhole site! Contamination & management

http://pasture.ecn.purdue.edu/~epados/farmstead/pest/src/avoidsink.htm Avoiding sinkholes

Cave and Karst Resources in the National Park Service:

www.nps.gov -> Nature Net-> Geology -> Geologic Resources Program -> Cave & Karst Program
or:
http://www2.nature.nps.gov/grd/geology/caves/index.htm

www.nps.gov/wica
Wind Cave National Park

www.nps.gov/jeca
Jewel Cave National Monument

www.nps.gov/maca
Mammoth Cave National Park

www.nps.gov/cave
Carlsbad Caverns National Park

www.nps.gov/grba
Great Basin National Park (Lehman Caves)

www.nps.gov/tica
Timpanogos Cave National Monument

www.nps.gov/seki
Sequoia and Kings Canyon National Parks

www.sequoiahistory.org/ccave.htm
Crystal Cave, in Sequoia-Kings Canyon NP

www.nps.gov/orca
Oregon Caves National Monument

www.nps.gov/ozar
Ozark National Scenic Riverways

www.nps.gov/havo
Hawaii Volcanoes National Park (lava tubes)

www.nps.gov/crmo
Craters of the Moon National Monument (lava tubes)

www.nps.gov/labe
Lava Beds National Monument (lava tubes)

www.nps.gov/pore
Point Reyes National Seashore (sea caves)

Cave Organizations:

www.caves.org
The National Speleological Society (NSS)

www.cavern.com
National Caves Association

www.cavern.org
American Cave Conservation Association

www.caves.org/section/ccms
NSS Cave Conservation & Management Section

Blanchard Springs Caverns

Dye Tracing

Objectives:

Students will:

- define how water can be traced as it moves underground.
- define parts-per-million and parts-per-billion.
- identify two dyes that are commonly used in hydrologic dye traces.

Arkansas Frameworks: ESS.8.4.1, ESS.8.4.6, ESS.8.4.7, ESS.8.7.8, ESS.8.7.14, ESS.8.7.16, ESS.8.7.17

Materials:

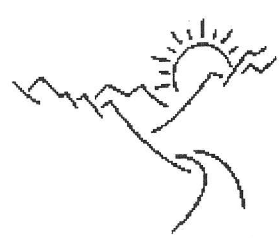
- Black light
- Eye dropper
- Sample bottles of rhodamine, fluorescein and optical brightener

Procedure:

1. Ask the students to imagine that they have a delicate cave under their land. The cave has several large pools, and water drips from the ceiling in many places. A rare species of blind cave fish lives in several pools in the cave. Two streams run through their property and disappear into the ground in the woods behind their house. The water in one stream is very cloudy and may be polluted. Do the students think the water from the streams is entering the cave? How can they find out?
2. Discuss hydrologic dye tracing. Show the students examples of rhodamine and fluorescein, two types of dyes that are often used in dye traces. Stress to the students that the dye is non-toxic and is used in very dilute concentrations.
3. The dye is fluorescent, and often an "optical brightener" (show students the sample bottle) is added to the dye to increase its fluorescence. Optical brightener is found in laundry detergents. It is the ingredient that makes your whites appear whiter and your brights appear brighter, by reflecting sunlight. Turn off the classroom lights and pull down the shades. Turn on the black light and walk around the room holding the brightener near students' clothes, demonstrating to each student that the optical brightener fluoresces. DO NOT SHINE THE BLACKLIGHT IN ANYONE'S EYES!!!!
4. Using the worksheet, the students will trace fluorescent dye from the streams into the cave. Have them predict how they will tell which stream is providing water to the different pools and drip sites in the cave. (They can put fluorescein in one stream and rhodamine in the other.)
5. How can the dye be detected once it enters the cave? In most cases, the dye will be so dilute that it will be invisible to the naked eye. The pools of water in the cave probably will not turn red or green. Can the fluorescence of the dye help in its detection? Tell the

students that samples of the water are brought out of the cave and to the surface where they are tested in a fluorometer. A fluorometer can be used to detect very small quantities of fluorescent dye in solution. A fluorometer is a machine that detects the amount of light that passes through the water. The dyes will reflect light at different wavelengths, making it possible to detect fluorescein and rhodamine separately.

6. A fluorometer can detect even a few parts-per-billion of rhodamine or fluorescein! What does this mean? Tell the students that if they put a single drop of dye into a 50'x25'x4.5' swimming pool, they have a 1 part-per-billion solution. 3 drops yields a 3 ppb solution. Certain dyes can only be detected in larger concentrations, such as a part-per-million. If you put one drop of dye into a 44-gallon barrel, you have a 1 ppm solution! You may wish to use an eye dropper to illustrate these concentrations.
7. Distribute copies of the attached worksheet. The students should color Sinking Stream green (representing fluorescein) and Pine Creek Stream red (representing rhodamine). Have the students use the data on the back of the worksheet to determine which pools and/or drip sites in the cave could be polluted. Why was testing done before the dye was injected? Discuss background levels of fluorescence. What might cause background levels? (Antifreeze [fluorescein makes it green; rhodamine makes it red] laundry detergents [with optical brighteners] or other chemicals that contain fluorescein or rhodamine would show up as background levels.) What seems to be the approximate background level of rhodamine in this case? Fluorescein? A positive dye concentration must be at least 3 times greater than the background level.
8. The students should color parts of the cave to illustrate the results of the dye trace. How do they think the water traveled through the limestone to reach particular sites in the cave? How long did the water take to reach the cave?
9. Have the students consider the following:
   What effect will the polluted water have on the cave? How can the pollution be cleaned up? How can the students identify the source of the pollution? How many other things could the pollutant be affecting? Will the pollutants stay in the cave or will they have a farther reaching effect? What will this do to the wildlife in the cave?
10. Building on what the students have learned in previous activities, discuss:
    What would happen if the limestone was covered with a layer of sandstone. How long might the water take to reach the cave? What effect will this have on the pollution? What about the wildlife? What about the cave in the future if the rock above is holding contaminants?
11. How can studies like this help the entire area in the future? Imagine real life place where dye tracing is taking place, places like show caves, national parks and national forests. By studying dye in the cave, what actions do you think will be made on the surface? Notice where the buildings are and where the water drains. Do you think information like this could help set limits of the numbers of people allowed to visit the cave? What about where they are able to park their vehicles? (Concerns about leaking oil, gas, antifreeze, or other pollutants.) What other benefits might come from a dye trace experiment?



Blanchard Springs Caverns

Focus on Watersheds

Objectives:

Students will:

- examine their surroundings.
- define what a watershed is.
- using the raised relief map, locate a watershed.
- discuss what local, regional and national watersheds are.

Arkansas Frameworks: ESS.8.4.1, ESS.8.4.6, ESS.8.4.7, ESS.8.7.8, ESS.8.7.14, ESS.8.7.16, ESS.8.7.17

Materials:

- Contour map
- Water container

Background:

A watershed is the land area that is drained by a stream or river. The borders of a watershed are called "divides", because they divide the water's flow. In gently sloping terrain, divides may be hardly noticeable. In other areas, like the example contour map area, the divides can be mountains. Most small watersheds contribute to larger watersheds. Water moves through the watershed as part of the water cycle. To keep water clean or to make sure there is plenty to drink, we need to understand where water comes from and how and where it flows.

Procedure:

1. Go outside and look at your surroundings. You can start anywhere - at home, school, or even downtown. Go to the highest point you can see within easy walking distance. If possible, go to the highest point in your community.
2. Look over the land and the way the ground slopes down from this high point. If it rained where would water flow? You are looking at a watershed or several watersheds. A watershed is the area of land where all water drains or "sheds" to the same body of water.
3. Does anything you see look like a possible water concern?
4. Brainstorm a list of the ways you can affect water. Be sure to think of activities inside and outside. Ask questions such as: What activities use water? What activities create wastewater? What do you already do to conserve or protect water? Two examples are: watering the grass and having a school car wash.

5. Using the raised relief map, have a volunteer slowly pour water on what they define as the high point or "divide" of the watershed. Have students discuss which way the water travels. Why is the high point of the watershed called a divide? What are the small watersheds that start the flow of water? What larger watersheds do the smaller ones flow into? A watershed can be large, for example, the Mississippi River drainage base, or very small, such as the 40 acres that drain to a farm pond. Large watersheds are often called basins and contain many smaller watersheds.

Extensions:

Now that you have begun to explore your watershed, take a look at how your community fits in. Investigate ways people have changed your watershed. Visit libraries, museums, and cultural centers, or talk with people who have lived in your watershed a long time. See if you can answer these questions:

- What kinds of jobs do people have in your watershed today?
- How did people make a living here fifty years ago? 100 years ago? 150 years ago?
- How has transportation changed in your watershed? How do people travel today?
- List three things you enjoy doing in your watershed. List three things you cannot do there.

Blanchard Springs Caverns

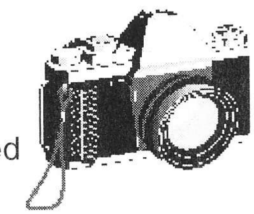
Getting the Groundwater Picture

Objectives:

Students will:

- define groundwater.
- define aquifer.
- observe how water travels through soil and becomes groundwater.
- compare the movement of water through diverse substrates.
- explain what the water table is.
- discuss how groundwater levels can fluctuate.

Materials:



- 2 large soda bottles with the bottoms cut off
- Rock and sand layered in the soda bottles as described
- Measuring cup
- A small piece of cheesecloth or pantyhose
- Pump (like a hand lotion pump)
- A container of water

Note:
The pump will not be used in this activity, however you will need it for Changing the Groundwater Levels and putting it in at this time reduces setup time. Keep the setup together for the Changing Groundwater Levels activity.

Background:
Groundwater is one of the Earth's most valuable natural resources. Many people think of groundwater as underground lakes or streams. These primarily exist where an area is underlain by cavernous limestone or lava tubes which will be discussed later. Most groundwater is simply water below the land surface that is filling all the spaces between rock gains or in the cracks and crevices in the rock. Groundwater is brought from the earth as well water.
Scientists use the word aquifer to describe the location of groundwater. An aquifer is an underground formation that stores and transmits water. Aquifers come in all shapes and sizes. Some may cover hundreds of miles while others may only cover a few square miles. Some areas may contain several aquifers located at different depths. The water quality and quantity in aquifers vary; even the ages of the water varies.
When specialists analyze the quality of groundwater, they consider land-use practices in the watershed. If pollution, such as hazardous waste, chemicals, heavy metals, etc. collect on the surface of the ground, rain or runoff can carry these substances into the groundwater.
How groundwater moves varies based on the rock material in the geologic formation where the water is located. Gravity and the pressure of overlying water cause the water to move. The water moves from a recharge area (where rain, streams, lakes, or karst areas carry it into the ground) to

a discharge area (where the water leaves the ground via springs, lakes, streams, etc). Groundwater moves toward areas of least resistance.

Procedure:

1. Using the 2-liter plastic bottle, construct a groundwater model. Cut off the bottom of the bottle. Cover the opening of the bottle with cheesecloth or a piece of old pantyhose. Put the lid back on the bottle. The opening will become the bottom of the groundwater model.
2. Place one cup of sand in the model. Have the students guess how much water the sandy aquifer will hold. Average their guesses. Measure the averaged guess in a measuring cup and show it to the students.
3. Slowly pour the measuring cup of water, or rain, over the sand. What happens? Does the water soak in? Can the jar filled with sand hold water? Why? How much water will the sand aquifer hold?
4. Pour more water (rain) over the sand. Watch the top of the aquifer rise until it forms a lake on the surface after the aquifer becomes saturated with the water from the rain.
5. Drain the water from the model by opening the lid on the bottom and letting the water seep out. Watch the aquifer recede as the water leaves the bottle. Pour the sand on a paper towel to dry.
6. Line the bottom of the model with larger rocks, next add the medium sized pebbles, then smaller pebbles, and last the sand. Using the rain can from *Water Filtration in Karst Areas,* sprinkle water on the model until the sand is saturated and the water begins to seep through the bottom of the bottle.
7. At various intervals, have the students stop pouring water onto the model. Ask the students to locate the top of the aquifer (called the water table).
8. Discuss how features on the surface could change how much water enters the aquifer. (Asphalt roads, concrete parking areas won't allow the water to seep into the ground. Vegetation might use the water.)

<u>Optional:</u>

You may want to use material to simulate soil and vegetation on the top of your model. For example, you could use a cloth on top of the sand to represent the absorbing nature of soil and vegetation.

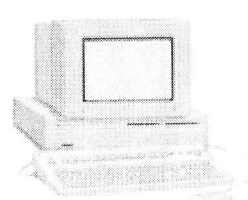
Blanchard Springs Caverns

Groundwater Internet Sites

Arkansas Frameworks: ESS.8.4.1, ESS.8.4.6, ESS.8.4.7, ESS.8.7.8, ESS.8.7.14, ESS.8.7.16, ESS.8.7.17

Using the EPA groundwater site (http://www.epa.gov/seahome/groundwater/src/basics.htm#menu), answer the following questions:

1. Define groundwater.
2. How much of the earth's freshwater supply is available as surface or ground water? How much of this is ground water?
3. Out of 10, how many public water systems get their water from wells?
4. What is a PWS?
5. How much water falls on the United States each day?
6. Does the earth ever lose water?
7. What is the water budget and what is the US water budget?
8. How much rain goes back into the ground annually? Should this affect the way we use water?
9. How much water is used in the US each day? Knowing how much water falls on the US each year, calculate how many days it takes to use the annual amount of precipitation. What percent of this water used goes back into the ground?
10. What percent of Americans live in the arid west? What percent of the US water do they use daily?
11. What is the zone where the term groundwater is used correctly?
12. What is an aquifer?
13. How much will groundwater typically flow each year?
14. What are some factors that influence recharge rate?
15. What is the downdraw and how is it helpful?



Blanchard Springs Caverns

Blanchard Springs Caverns

Groundwater Internet Sites

Answers:

1. Groundwater is the water held in the interconnected openings of saturated rock beneath land surface. (Hydrogeologic Menu Section)
2. 1% of the earth's water is available fresh water; 2/3 is groundwater
3. 9 out of 10 public water systems use wells
4. Public Water System
5. 4.2 trillion gallons of water falls on the US each day
6. No, the volume of water is constant on the earth, it just changes form or moves
7. The water budget is the amount of water received annually for an area. The US water budget would cover the entire country in 30 inches of water
8. Only 0.1 of an inch goes back into the groundwater. We should keep this in mind when we are thinking about irrigation, well use, etc.
9. 450 billion gallons of water are withdrawn each day. It takes less than 10 days to use the annual amount of precipitation. About ¾ of this water is returned.
10. 28% of the population lives in the west and they use 80% of the nation's water
11. The saturated zone is the term
12. An aquifer is a rock unit that will yield water in usable quantities to wells or springs
13. Unlike fast moving surface water, groundwater will flow several inches to several feet a year. (Water Movement in Aquifer Section)
14. Recharge can be affected by: characteristics of soil, plant cover, slope, water on the surface, amount of rainfall, presence of confining layers and aquifers (How Aquifers are Replenished Section)
15. Downdraw is the vertical drop in height between water level in a well before pumping and the level during pumping. It helps ensure continuous supply of water, helps identify overlying land for management purposes, and could show change in a water source (Groundwater and Wells Section)

Blanchard Springs Caverns

Make a Cave

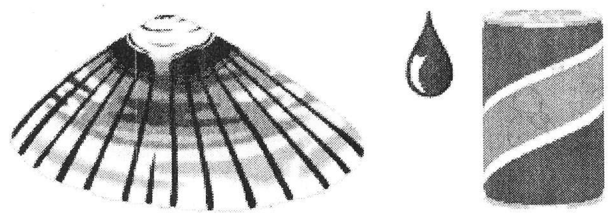
Objective:

Students will demonstrate how carbonic acid can slowly dissolve limestone and form caves.

Arkansas Frameworks: NS1.4.3, NS1.4.5, NS1.4.12, LS4.6.2

Materials:

- A piece of limestone, preferably with an imbedded fossil
- Water
- Soda pop, preferably clear



Procedure:

1. Show the class the example of limestone. Pass it around the room and allow each student to closely examine it. Review how limestone forms.
2. Ask the students how caves are formed in limestone. (Water dissolves the rock.) Pour water over the limestone. What happens? Do we have a cave? No, we have a wet rock! By itself, water cannot dissolve limestone. What else do we need?
3. From completing the "<u>Make Carbonic Acid</u>" activity, the students should remember that carbon dioxide in the soil can change the water into carbonic acid. What will happen when carbonic acid seeps through the soil and reaches the underlying bedrock? If this bedrock is limestone (or another carbonate rock), it will slowly dissolve it.
4. Ask the class where they might find carbonic acid in their every-day lives. Soda pop is acidic because it contains carbonated water, or carbonic acid.
5. Pour the soda pop over the limestone. Make sure that every student has a chance to see the limestone fizz & slowly dissolve. The soda will fizz on any material, but the acid will dissolve the rock. You could use hydrochloric acid in a demonstration, but if you do make sure the student follow all the safety procedures.
6. Discuss how carbonic acid can travel through the limestone (via cracks) and create cave passages.

Blanchard Springs Caverns

Making Carbonic Acid

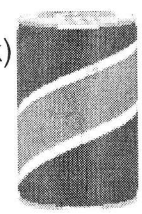
Objectives:

Students will:

- investigate the concepts of pH, acidity, and alkalinity.
- demonstrate how carbonic acid is formed.
- describe how carbonic acid can dissolve limestone to create caves.

Materials:

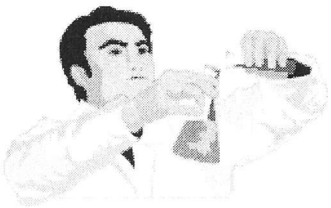
- Litmus paper
- Small cups, one per student
- Straws, one per student (coffee stirrers will work)
- Soda water or soda pop, preferably clear
- Flat soda water or soda pop
- Vinegar
- Distilled water
- Baking soda



Procedure:

1. Ask the students, "What is an acid?" Discuss the concept of acidity. What acids are the students familiar with? Discuss citric acid, stomach acids, battery acids, etc. Discuss what makes acids acidic (many hydrogen ions in solution). What are characteristics of most acids?
2. What are bases? Discuss alkalinity. What makes bases basic? (Many hydroxides in solution.) Draw the pH scale on the board, from 0 to 14. Refer to the attached chart to associate pH values with hydrogen ions with familiar household substances. This should help the students get better control of the concepts. Discuss the meaning of the numbers in the scale. (1 x 10-7 hydrogen ions in solution = pH 7, where the parts of H+ are 0.0000001 and for a pH of 2 the parts of H+ are 0.01 making it more acidic, etc.) The lower the pH, the higher the acidity. 7 is neutral. (Acid is low 1-7, base is high 7-14, just like "a" before "b" in the alphabet.) Decide what information your students would benefit the most from. Younger students do not need to be introduced to the ions in solution information, etc.
3. Divide the students into groups of three. Give each student a small cup of vinegar, a small cup of distilled water, a small cup of baking soda/water solution, and 3 pieces of litmus paper. The litmus paper will turn red in an acid, blue in a base, and remain the same in a neutral solution.
4. Have the students dip a piece of litmus paper in each cup and quickly remove it. The color change should be instantaneous. Discuss what each student tested. Did they find the solution to be acid or base? How did they come to that conclusion?

5. Next, discuss how water can become acidic. What chemical transformation needs to take place? (The hydrogens need to dissociate from the oxygen.) What happens when water mixes with carbon dioxide? Write the equation on the board. H2O + CO2 ->H2CO3 (carbonic acid) The hydrogens are now bonded to carbon instead of oxygen.
6. Give each student a straw or coffee stirrer and another piece of litmus paper. Have them blow bubbles into their cup of distilled water for approximately one minute, then test with litmus paper. Did the paper turn red? Why? (Testing the water needs to happen while the students are blowing into the water or immediately after the students stops.)



7. Ask the students if they are familiar with carbonic acid. What is it? - soda pop. Why is soda pop fizzy? It is mostly carbonated water, carbonic acid - water is mixed with carbon dioxide under pressure. Give each student a small cup of soda and have them test for acidity with a fresh piece of litmus paper. Does it turn red? Is it more red than the paper from step #6?
8. What happens when soda goes flat? Give each student a small cup of flat soda, and have them test it with litmus paper. What color is it? Why?
9. How might water turn to carbonic acid in nature? Discuss the conversion of water to carbonic acid as it seeps through soil. Water from snow melt or rain will pick up carbon dioxide (from decaying plants and other organic material) as it travels through the soil.
10. Where does the carbonic acid go once it passes through the soil? It will hit the bedrock. If this bedrock is limestone (or another carbonate rock), the carbonic acid will slowly dissolve it. Is there acid in the cave today? Why or why not? Think about the degassing process.
11. Next, complete the "<u>Make a Cave</u>" activity.

The pH scale is used to measure acids and bases. The scale runs from 0 (very strong acid) to 14 (very strong base). Seven is the neutral point on the pH scale. Run your mouse over the pH scale below to learn more about acids and bases.

	ph	
Strongest Acid	**0**	1 x 10^{-0} hydrogen ions Example – hydrochloric acid @4%
	1	1 x 10^{-1} hydrogen ions Example – stomach acid
	2	1 x 10^{-2} hydrogen ions Example – lemon juice
	3	1 x 10^{-3} hydrogen ions Example – vinegar
	4	1 x 10^{-4} hydrogen ions Example – soda pop
	5	1 x 10^{-5} hydrogen ions Example – rainwater
	6	1 x 10^{-6} hydrogen ions Example – milk

Neutral	**7**	1 x 10^{-7} hydrogen ions Example – pure water
	8	1 x 10^{-8} hydrogen ions Example – egg whites
	9	1 x 10^{-9} hydrogen ions Example – baking soda
	10	1 x 10^{-10} hydrogen ions Example – ammonia
	11	1 x 10^{-11} hydrogen ions
	12	1 x 10^{-12} hydrogen ions Example – Drano®
	13	1 x 10^{-13} hydrogen ions Example – sodium hydroxide
Strongest Base	**14**	1 x 10^{-14} hydrogen ions

Blanchard Springs Caverns

Mysterious Polluter

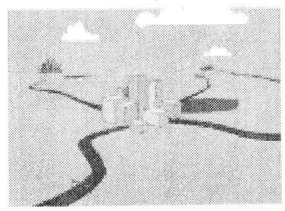
Objectives:

Students will:

- identify several common pollutants
- identify the difference between point source and non-point source pollution

Materials:

- Plastic box and lid (approximately 9x14x6)
- 1 lb sand
- Water
- 1 liter (quart) container for water
- Two 10cc syringes (without needle)
- Baking soda
- Vinegar
- Small cup for vinegar
- Teaspoon
- Eye dropper
- Ice cube tray
- Colored toothpicks or Monopoly game houses
- Food coloring (not yellow)
- Spray bottle of water



Background:

Review the two kinds of pollution, point source and non-point source. Point source comes from a specific source like a discharge pipe at a factory. These sources are relatively easy to locate. Non-point source pollution is associated with sources not easy to locate, surface water runoff from streets after rain or snow or runoff from fields tainted such as animal wastes, pesticides, etc.

Procedure:
To keep the pollution location a secret, steps 1-4 should be completed without student involvement.

1. Fill the box about 1/3 full of sand and wet it until completely damp.
2. Make the sand high at one end and low at the other.
3. Secretly bury a teaspoon of baking soda in the hill end, but not too deep, and mark it with a toothpick or house to represent a house with a well.
4. Add 4 or 5 other houses to the surface.
5. Have a student read the story below.

6. Have the students test the water by using the syringe to draw water out at each house. Place a few drops from the test well to an ice cube tray then, using an eyedropper, add a few drops of the "pollution indicator" (vinegar) to each test area.
7. When the pollution indicator makes the water fizz, you have found the pollutant
8. Ask the students how you would clean up the pollutant and how they would keep the neighborhood water from being polluted again.

Discussion:

- Which type of pollution did they just find?
- Which type is easier to fix?
- What is the best way to prevent these types of pollution? (Education)
- Since you know your groundwater is polluted and where it is coming from, where will you choose to put your well?
- What if you are using a municipal system, where will you get water?
- How will you decide where to get water?
- Can you clean the water in your area?
- Can you clean it in your well?
- Will you have to truck water into your area?
- How will you work to solve this problem - would you have to create an emergency response plan that was presented to the city council - what would you recommend?

To provide an example of point source pollution, have the students perform a second experiment. Add 5 drops of food coloring to one end of the box and, using a spray bottle, lightly mist the colored area. Watch the water spread through the box. It should fan out as point source pollution would.

The Story

The people in your town have asked you to help them. Someone has been dumping some leftover chemicals in their backyard. This is beginning to pollute a whole neighborhood's water supply. Several people have already gotten sick from drinking the polluted water. Because of this, no one can use any water until there is no more pollution or until the pollution levels dramatically decrease. Although the town residents have been trying to clean up the water, they can't be completely successful until they have found the source of the pollution. Since no one in the town will admit to being the source, the town has called you in to do some environmental detective work. You must test the water near each of the houses by taking a sample from each well. Put the sample in the mixing tray and add the "pollution indicator" to it. If the water by that house is polluted, your sample will fizz.

Blanchard Springs Caverns

Sand and Surf

Objective:

Students will discover the ratio of land to water on the Earth's surface.

Arkansas Frameworks: ESS.8.4.1, ESS.8.4.6, ESS.8.4.7, ESS.8.7.8, ESS.8.7.14, ESS.8.7.16, ESS.8.7.17

Materials:

- Beach ball globe
- Surf n' Sand Toss worksheets (1 per student)

Procedure:

1. Tell the class that they will conduct a probability experiment to calculate the ratio of land to water on the Earth's surface. What percent of the Earth do they think is covered by water? By land?
2. Have the students toss and catch the globe 50 times. Be sure that the ball is spun as it is tossed. Each time the ball is caught, have the catcher call out the location of their right index finger (land or water). Keep a tally of the results on the board.
3. At the end of the first trial, have the students record the results on the attached AIMS worksheet. Complete two more trials.
4. The average percentages of land and water for the beach ball experiment should roughly equal the actual percentages of land and water on the Earth. Over 70% of the Earth's surface is covered by water!

Printed with permission from Wind Cave National Park from http://www.nps.gov/archive/wica/Hydrology_Introduction_Why_Water.htm on 6-23-09.

Name____________________________

Sand'n'Surf Toss

If a beach ball globe is tossed and caught, what percent of the time will the catcher's right index finger be on water?

Do three trials in which the globe is tossed and caught 50 times. Keep a tally of the results in the first table and then calculate the percent in the second table.

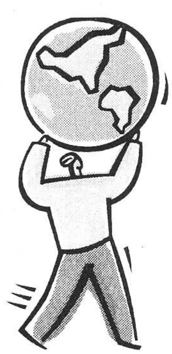
Tally

Trial	Land	Water
1		
2		
3		

Percents

Trial	Land/Total	Percent Land	Water/Total	Percent Water
1				
2				
3				

Average [ ] Average [ ]



Blanchard Springs Caverns

Soil Layers and Groundwater

Objectives:

Students will:

- compare the difference in various soil types.
- analyze how infiltration changes with different soil types.
- describe the challenges of recharging a water table due to various rock types.

Arkansas Frameworks: ESS.8.4.1, ESS.8.4.6, ESS.8.4.7, ESS.8.7.8, ESS.8.7.14, ESS. 8.7.16, ESS.8.7.17

Materials:

- Four large paper (or plastic) cups
- 1 cup gravel
- 1 cup sand
- 1 cup topsoil
- 1 cup clay soil
- shallow pan
- food coloring
- magnifying lens
- quart of water
- stopwatch

Procedure:

1. Discuss various rock and soil types found in the ground above the water table. Some examples are sand, silt, clay, gravel, limestone, sandstone, granite, etc. Realizing that there are many layers between the ground and the water, ask the students if it is easy for water to reach the water table. Predict which of the soil types will be the fastest and slowest for the water to travel through. Do you think these exist under the earth where you live?
2. Have the students examine each type of soil. Have them rub a pinch between their fingers. What do they feel like? What do they smell like? Investigate each under the magnifying lens. How large is a particle of each one? A sand particle is about 0.4 mm, clay is about 0.004 mm per particle. Which would hold more water between the particles? Which would hold the least?
3. Punch four small holes in each of the cups and fill each cup with one type of soil material.
4. Place about 4 drops of food coloring in a quart jar of water. Place ½ cup of colored water into the measuring cup.
5. Have one of the students get ready with a stopwatch to time the procedure. Hold one of the cups over the pan and pour ¼ cup of the colored water into the cup. Time how long it takes the

first colored water to reach the pan. Measure the amount of water that collected in the pan. Record your information.

6. Repeat procedure for all four cups.
7. Discuss the following: Which one took the longest? Which type of soil returned the most water to the pan? Why? When does water enter the soil? What happens when water moves through the soil layers? Is this an easy path for water to take? Can water move through all types of layers? Why or why not? What would happen if the water were to intercept a cave? Can the soil layers clean the water? Do various soil types have any cleaning qualities? How? (Bacteria, sediment and other insoluble forms of contamination get trapped in the soil pores; some chemicals are absorbed or react with the soil and are prevented from entering the groundwater; plants and soils use potential pollutants like nitrogen as nutrients decreasing the amount that gets into the water). Which type of soil would be most efficient at cleaning water? What events on the surface could cause the water to need to be cleaned? What happens if these contaminants get into a cave?
8. Recharge rates of water tables depends on the amount and rate of water moving through the surface, soil, and rocks beneath. Discuss the following: Which is better - a fast rate of recharge or a slow one? Why? Would water be more contaminated with faster recharge or slower? What is the benefit of having a slower recharge rate? A faster rate? How will an aquifer fill if there is a lot of water being removed quickly? In real life, how do people balance these issues?

Blanchard Springs Caverns

The Water Race

Objectives:

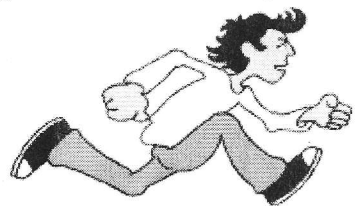
Students will:

- define permeability and porosity.
- predict and test permeability of different rock types.
- relate makeup of rock layers and use of the area to permeability.

Arkansas Frameworks: ESS.8.4.1, ESS.8.4.6, ESS.8.4.7, ESS.8.7.8, ESS.8.7.14, ESS.8.7.16, ESS.8.7.17

Materials:

- 2 (20 oz) plastic soda bottles with large openings - one filled with gravel, one filled with sand
- 2 (20-oz) plastic soda bottles filled with water
- pieces of sandstone
- pieces of limestone
- geology cards



Background:

Water moves in a continuous cycle between the air, ground, plants, and animals. The roots of a plant might use the water that soaks into the earth. But if no plant captures the water, it might travel downward through the rocks and soil. The movement is called infiltration. The rate that water travels through the rock depends on the permeability of the rock layers. The spaces, or pores, in the rock allow the water to travel through it. If we magnify rocks such as limestone or sandstone many times, we would see that they are full of tiny holes. These spaces have an enormous ability to carry and hold water. The measure of space available to hold water is called porosity. Igneous rocks, like granite, have formed in such a manner that the minerals are very close together and water can not easily get into it. Sandstone is very porous; the water will be easily soaked up within the spaces or pores of the rock.

How easily the water travels through the rock is called the permeability. In rocks, permeability depends on the size of the pores and on how connected they are to one another. Rocks, such as limestone are porous but they also crack very easily allowing the water to travel through. Rocks often associated with caves are limestone, sandstone and shale or clay. Shale or clay is impermeable; the water will not travel easily through the rock.

How the water travels through the rock determines how much water gets into the ground. The availability of groundwater varies in different areas of the world and is determined by the permeability or porosity of the type of rock in that area. We will be investigating groundwater in limestone and sandstone. Bedrock can also filter water as it seeps into the ground encountering the different rock types.

Procedure:

1. Have the student investigate the piece of sandstone. How does it feel? Is it gritty or sandy? Slowly pour water on it. What happens to the water? Why? Show the students the cards and ask them which illustration represents sandstone. Have them recall how sandstone forms.
2. Have the students investigate the limestone. How does it feel? Have them slowly pour water on the limestone. What happened to the water? Why? Since most caves form in limestone ask them to predict how the water could get into the rock level. Show the students the cards and ask them which illustration represents limestone. Have them recall how limestone forms.
3. Have the students investigate a piece of clay. How does it feel? Does it feel like either of the other rocks? Have them pour water on the clay. What happened to the water? Why? Show them the cards and ask them which illustration represents clay. How does shale or clay form?
4. Show students the bottle of sand and the bottle of gravel. Ask them to determine which type of rock each bottle represents - limestone or sandstone. Ask the student to predict which type of rock they think the water will travel through the fastest.
5. Ask for 4 volunteers to perform the water race. The volunteers will form pairs, one pair with the sandstone, one with the limestone. One person will hold the rock bottle; the other person will slowly pour water into the rock bottle. The other team will be arranged the same.
6. When everyone is ready have the students with the water bottles pour water into the rock bottles without spilling any water. When one group "wins" the race by pouring all of their water into the rock bottle, have the other group stop. Discuss why the group won. What does that say about the permeability of the rock? How will the permeability of the rock affect the quality of the water entering into groundwater?

Discussion:

- Can bedrock affect the amount or rate of contamination to the groundwater?
- Would sandstone or limestone allow more contaminants?
- Which one would allow the contaminants to get there faster?
- Could this have an effect on a cave?
- What if there were a parking lot or houses over the cave?

Blanchard Springs Caverns

Water Filtration in Karst Areas

Objectives:

Students will:

- investigate to what extent water is filtered through different rock types.
- define porosity and permeability.
- examine how caves and sinkholes direct water flow.
- analyze why groundwater in karst areas is at greater risk of contamination.
- identify several sources of pollution.

Arkansas Frameworks: ESS.8.4.1, ESS.8.4.6, ESS.8.4.7, ESS.8.7.8, ESS.8.7.14, ESS.8.7.16, ESS.8.7.17

Materials:

- 2 2-liter clear plastic soda bottles with bottoms cut off (the bottles from "Getting the Groundwater Picture" can be used.)
- 3 squares of flexible nylon screening (~3 inches of screening from a screen door would work)
- 2 rubber bands
- A small piece of cheesecloth or pantyhose squares or flexible nylon screening (~3 inches)
- Large pebbles (about 4 cups)
- Small pebbles (about 4 cups)
- Coarse sand (about 4 cups)
- 2 large, graduated beakers (500 ml)
- 1 4-inch piece of 1-inch diameter flexible plastic tubing (piece of garden hose)
- 1 small funnel (~3 inch diameter, with stem that fits into tubing)
- Rain cans (tin cans with holes in the bottom)
- ½ cup vegetable oil
- ½ cup coffee grounds
- Red food coloring
- Pitchers or other containers to mix "contaminated water" (preferably clear)
- Photographs of sinkhole plains and polluted sinkholes

Procedure:
To keep the cave location a secret, steps 1-4 should be completed without student involvement.

1. With a rubber band, secure a piece of nylon screening (cheesecloth will work) over the mouth of each 2-liter bottle.
2. Set the bottles, inverted, in the empty beakers or jars. Label them "#1" and "#2."

3. Fill each bottle with identical rock layers. Start with large pebbles, then add a layer of small pebbles. In one bottle, bury tubing in the layer of small pebbles (see figure). Cover the top opening of the tubing with a square of nylon mesh or pantyhose (tie a string onto the rubber band holding the square for easy removal later - hide the string). This becomes the secret cave. Finish with a thin layer of sand.
4. Mix up three different "pollutant" types and label the containers:
   - ½ cup vegetable oil with 6 cups of water ("Oil")
   - ½ cup coffee with 6 cups of water ("Sewage")
   - several drops of food coloring with 6 cups of water ("Pesticides/Herbicides")
5. During class discuss the "rock types" in the bottles. Which type is the most porous? Permeable? Tell them that the rocks represent limestone and sandstone. The limestone is very permeable and cracked. Sandstone is very porous. Ask students how porosity and permeability may affect filtration. If porosity and permeability are new concepts, write the definitions on the board.
6. Tell students that one bottle contains a cave, while the other does not. Ask them which rock layer most likely contains the cave. Review the definition of karst. Have students predict which bottle will act as a better filter.
7. Show the students the containers of contaminated water. Discuss how water can become polluted. What happens when rain falls on a parking lot? Where does the oil go? Discuss how water can become brown and cloudy. What does the water look like that runs off of a cow pasture? What if a septic tank leaked? Where would the sewage go? What happens to pesticides when it rains soon after pesticides are applied? Remember, not all pesticides contaminate the water. (For questions on this topic, consult your county extension agent.)
8. Have two volunteers assist you. Give each student 2 cups of the coffee water in the rain cans. Have each student hold their water over the bottles as it slowly sinks in and time the drainage. When water stops dripping into the beakers, show them to the class. Which bottle acted as a better filter? Which beaker contains more water? If one or both beakers contains less than 2 cups of water, where did the rest go? Were the results different for the two bottles? Have students record the results on the attached worksheet.
9. Pour out the beakers. Repeat step 8 using oily water, then red water.
10. Ask students which bottle contains a cave. How do they know?
11. Remove the nylon screen from the tubing. Fit the small funnel into the tubing and tell the class that the funnel represents a sinkhole. Define sinkholes. Show the class the pictures of sinkhole plains. Cover the funnel with the nylon screen and a thin layer of sand.
12. Have a student pour 2 cups of coffee water into the "karst" bottle. Discuss the results. Repeat with the oily and red water.
13. Discuss how water is filtered as it passes through rock. How well is water filtered in karst areas? Would pollution be of greater concern in a karst area, or a non-karst area? Were the pesticides filtered out in either bottle?
14. Show students the picture(s) of polluted sinkholes. Why might it be a bad idea to throw trash into sinkholes?
15. <u>Water Filtration Worksheet</u>

Water Filtration in Karst Areas

Vater Filtration Worksheet

Name
Date

Sample	Appearance of Water	Amount of Water	Time
Bottle 1 Water with 'Sewage' Contaminant			
Bottle 2 Water with 'Sewage' Contaminant			
Bottle 1 Water with 'Oil' Contaminant			
Bottle 2 Water with 'Oil' Contaminant			
Bottle 1 Water with 'Pesticide' Contaminant			
Bottle 2 Water with 'Pesticide' Contaminant			
Bottle with Sinkhole Water with 'Sewage' Contaminant			
Bottle with Sinkhole Water with 'Oil' Contaminant			
Bottle with Sinkhole Water with 'Pesticide' Contaminant			

Questions:

1. Which bottle contained the cave? (#1 or #2?)
2. Which bottle filtered the contaminants the best? Why?
3. Which contaminant was most difficult to filter out? Why
4. What are some examples of other pollutants that could affect groundwater?
5. Why is clean groundwater important?
6. Define: Karst, Sinkhole, Porosity, Permeability. How does each affect underground water flow and filtration?

Blanchard Springs Caverns

Water Use Internet Sites

From http://ga.water.usgs.gov/edu, follow the links to find the answers to the following questions. (Hint: The Water-Use Info, Water Q&A, and Activity Center links will be most helpful!) Use this activity as a scavenger hunt with the student finding all of the answers winning a prize.

1. What is the total amount of water (in gallons per day) used by your state?
2. How much water per day is used by your state for irrigation?
3. Approximately how much water does each person use at home per day?
4. Is more water used each day by taking showers, taking baths, or flushing toilets?
5. How many gallons of water per year does 1 leaky faucet in 1 home waste if it drips 5 times/minute?
6. If 500 homes in your community each have 1 leaky faucet that drips 3 times/minute, how much water is wasted per year?
7. What is most of the freshwater in the United States used for?
8. Which state uses the most water?
9. How much water does it take to make a hamburger?

Answers:

1. Arkansas uses 5,000 to 10,000 million gallons of water per day.
2. Arkansas uses 1,000 to 5,000 million gallons a day.
3. Arkansans use 0 to 50 million gallons a day.
4. Flushing toilets.
5. 173 gallons a year.
6. 52,073 gallons a year.
7. Irrigation.
8. California.
9. 13000 gallons is a good guess, but there are a number of estimates:
   Thirty years ago, the Water Education Foundation offered up an answer of 1,300 gallons,
   and in an additional study in 1991 came up with another estimate of about 620 gallons.
   The California Beef Council sponsored a study that produced a number of just over 100 gallons,
   though that number excludes rainwater.

Blanchard Springs Caverns

Water Works

Objectives:

In this modified Project WET activity, students will:

- examine the many different ways to use water.
- discuss the impact each one has on other water users.

Materials:

- Two jugs of water - one labeled "ground water," the other labeled "surface water" (one gallon milk containers will work)
- Ball of string or yarn
- *Description of Water Users* cards (pasted on 3 x 5 cards)

Procedure:

1. Have students make a list of the different ways they use water. Introduce the concept that water can be used both directly (washing your hands) and indirectly (eating an apple). After mentioning this, add to the original list.
2. Pass out *Water Users* cards giving one to each student. Have the students silently read the description of his or her water user. Ask water users to consider how they depend on products and services supplied by other users.
3. Have students stand in a circle around the water jugs. Attach the jugs by the handles with the yarn. The teacher will stand in the middle at the jugs. Explain that the jugs represent all water and the yarn represents our need for water.
4. Select a student to describe the goods or services his or her water user provides and how they use water. Pass the ball of yarn to that student. Have them wrap the yarn loosely around one finger and then pass it back to the center. In the center, wrap the yarn around the jug handles one time.
5. After each student has done this, pass the yarn to one student. Have that student read his or her card. Ask the other students to raise their hands if they use the goods or service offered by that student. Have the person with the yarn pass the ball of yarn to one of the students who raised their hand. (The student passing the yarn should hold on to the yarn so he/she is connected to the new student.) Repeat this until all of the students are connected.
6. To emphasize the interdependence of the water users, ask one student to tug gently on their section of yarn. Ask the other students if they can feel it. If they can, have them tug on their yarn. They will understand that all water users are connected and that we all depend on each other to enjoy our fair share of water.
7. If the water jugs in the middle ever get raised up or tip over, explain that the water supply is being overextended. The users are using too much water and the supply is feeling the stress.

Extension:

At lunchtime, ask the students to bring back one item from their lunch. It can be anything from a can to a bag to a granola bar to a piece of fruit. Ask the students to get into 4 groups. From those four groups, ask each student to choose one item that was brought back from lunch. Ask the groups to make a diagram of how that item got to them today and how much water it took to make it. Encourage them to think of every step of the process, including any farming, mining, transporting, coloration, etc. Allow them time to discover these steps before you suggest them. Have each group make a presentation to the class.

Printed with permission from Wind Cave National Park from http://www.nps.gov/archive/wica/Hydrology_Introduction_Why_Water.htm on 6-23-09.

Description of Water Users (for Water Works activity)

In addition to the descriptions listed below, students may research a specific water user during the week prior to this activity.

Agriculture: Water is used to produce food and fiber for processing and consumption.

Sugar cane grower: Uses water to irrigate crops and transport chemicals (pesticides and fertilizers) to crops.

Cattle rancher: Uses water to grow food and provide drinking water for cattle, and to clean their areas for living and feeding, transporting water to holding ponds.

Fish farmer: Uses water to raise fish to maturity in rearing ponds, and to carry waste from the ponds.

Wheat farmer: uses water to irrigate crops.

Dairy farmer: Uses water to grow food and provide drinking water to cows, and to sanitize milking equipment and stalls.

Logging: Water is used to grow and harvest trees.

Forest manager: Uses water to support tree growth and control fires.

Logging company: Uses water to float rafts of logs (on rivers and lakes) to collection points.

Transporting/Shipping: Water (rivers, seas, oceans) is used to transport raw materials and finished products to points of distribution (ports).

Slurry pipeline owner: Uses water to transport pulverized coal through pipelines to distant coal-fired power plants

Ship's crew: Uses water to haul raw materials (e.g., logs, oil, gas, wheat) and finished products (e.g., automobiles, appliances, processed food) to points of transfer.

Mining: Water is used in the extraction process of raw materials (coal, iron, gold, copper, sand, and gravel).

Miner: Uses water to carry and wash rock material during he mineral removal process.

Sand and gravel company: Uses water to wash fine soil and rock material out of sand and gravel formations. Sand and gravel are used in cement and road construction.

Business/Industry: Water is used in the processing and manufacturing of goods (cars, food, medical supplies, etc.).

Steel producer: Uses large volumes of water to process iron ore into steel.

Textile manufacturer: Uses water to wash and process raw materials (e.g., wool, cotton, mohair). Dye is mixed with water to color fabric.

Soft drink company: Uses water to produce soft drinks and to sanitize equipment.

Paper mill: Uses water to transport pulp fibers for paper making and to carry away waste.

Chemical manufacturer: Uses water in the production of pesticides and fertilizers.

Wildlife: Water provides habitat for countless plant and animal species.

Mammals: Beavers, muskrats, and otters live in and near waterways.

Fish: Trout, salmon, and carp live in water and eat organisms that live in water.

Insects: Aquatic insects are a food source for many other organisms.

Vegetation: Trees and other plants use water in photosynthesis and to transport nutrients.

Power Generation: Water is used to generate electricity.

Hydropower plant: Water flowing in rivers is stored behind dams in reservoirs. As water is released by the dam, it turns turbines that generate electricity.

Nuclear power plant: Uses water in cooling towers to maintain safe operating temperatures.

Coal-fired power plant: Burning coal produces steam heat that turns turbines, creating electricity.

Recreation: People recreate in and around water for exercise and enjoyment.

Cruise ship: People travel to many parts of the world in cruise ships.

Fishing: People catch fish in rivers, lakes, and oceans.

Water theme park: Uses water to transport people on exciting and fun rides.

Scuba diver: People enjoy exploring underwater environments.

Winter sports: Snow and ice provide fun for skaters, skiers, and sledders.

Community: Water is used by community members for domestic, maintenance, and recreational purposes.

Domestic users: Water is used in a multitude of ways in and around the house.

Fire department: Uses water to extinguish fires.

Street cleaner: Uses waster to wash oil, litter, and other materials from streets.

Restaurant owner: Uses water to cook meals, clean the kitchen, wash tables and floors, and water lawns.

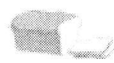
Park: Uses water in fountains and reflecting ponds and for landscaping needs.

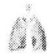
Blanchard Springs Caverns

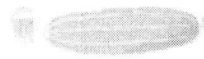
Why Water?

Arkansas Frameworks: ESS.8.4.1, ESS.8.4.6, ESS.8.4.7, ESS.8.7.8, ESS.8.7.14, ESS.8.7.16, ESS.8.7.17

Water makes all life possible and connects all living things through time. Water is a never-ending cycle being reused. The water in a cave today is the water that the dinosaurs drank, that the ancient Egyptians used, and that you will use for dinner when you are 80. Here are some interesting facts about water.

- The average person uses about 100 gallons of water each day
- It takes: 25 gallons of water to make one ear of corn 
- 1300 gallons of water for one hamburger 
- 2607 gallons of water for one pound of beef 
- 815 gallons of water for one pound of chicken 
- 65 gallons of water for a gallon of milk
- 100 gallons of water for a watermelon 
- 120 gallons of water for one egg
- 1000 gallons of water for a two pound loaf of bread 
- 80 gallons of water to make one Sunday newspaper 
- 1800 gallons of water to make a pair of cotton jeans
- 100,000 gallons of water to make a new car 

- Water weighs about 8 pounds a gallon
- One half of the world's fresh water is in Canada 
- 20% of the available fresh water of the world is in the Great Lakes
- 60% of the fresh water in the world is used for irrigation
- California accounts for 20% of the nation's irrigation
- 60% or more of the human body is water
- 70% of the human brain is water
- 82% of the blood is water
- 90% of the lungs are water 

- A leaky faucet dripping 20 times a minute will waste close to 700 gallons of water a year 
- 40% of household water is flushed down the toilet 
- Water is the only substance on Earth that naturally exists in all three states: solid, liquid, and gas.
- A jellyfish and a cucumber are each 95% water! 
- Each day 4,200,000,000,000 gallons of water falls in the US and 70% of it is evaporated or used by plants
- Water levels in the Midwest Aquifer have dropped over 1000 feet due to over-consumption
- *Did you know that each year people who change their own oil throw away 11 times the amount of oil spilled by the Exxon Valdez? This oil can easily pollute surface and groundwater.*
- *Did you know that nearly one half of the world's population lacks access to clean water for sanitation, drinking and other human needs?*
- *Did you know that using hot water straight from the tap for cooking or anything else is not healthy because lead from the plumbing can get into hot water?*
- *Did you know that more than 200 million pounds of contaminants are dumped into our water resources every year?*
- *Did you know it can take up to 45 minutes for a water supplier to produce one glass of drinking water?*
- *Did you know that water expands by 9% when it freezes?*
- *Did you know that only 1% of the earth's water is drinkable?*