



Caves Under Construction

The Science of Cave Formation

Materials

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

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

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

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

Teacher Background on Cave Formation

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

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

Caverns form under the surface of the ground in the





underlying bedrock and may not have an opening. Most entrances form after the cavern itself forms. Entrances can be caused by the collapse of a sinkhole, by erosion of a hillside, or they can be man-made.

The following experiments introduce students to the chemistry and geology associated with the formation of solution caves in limestone.

Soluble Stuff

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

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

Vanishing Rocks

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

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

Speleothem Garden

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

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





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

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

Constructing Karst

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

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





Karst Vocabulary Review Answer Key

sinkhole

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

limestone

a rock made up mainly of calcite from ocean animals

solution

a type of mixture where the material cannot be filtered out

dissolve

to disintegrate or break up

bedrock

the solid rock beneath the looser soils on the earth's surface

carbonic acid

important for the formation of cave "decorations"

calcite

many cave formations are made of this mineral

speleothems

a fancy word for cave formations

topography

the shape and physical features of the land

cavernr

these form in soluble rock and can grow speleothems

evaporate

to change into a vapor or a gas

springg

an issuing of water from the ground

swallow hole

place where a stream disappears underground

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

karst topography





Name _____

Karst Vocabulary Review

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

- ____ _____ a depression in the surface of the ground caused by dissolving of the rocks beneath
- ____ _____ a rock made up mainly of calcite from ocean animals
- ____ _____ a type of mixture where the material cannot be filtered out
- ____ _____ to disintegrate or break up
- ____ _____ the solid rock beneath the looser soils on the earth's surface
- ____ _____ _____ important for the formation of cave "decorations"
- ____ _____ many cave formations are made of this mineral
- ____ _____ a fancy word for cave formations
- ____ _____ the shape and physical features of the land
- ____ _____ these form in soluble rock and can grow speleothems
- ____ _____ to change into a vapor or a gas
- ____ _____ an issuing of water from the ground
- ____ _____ _____ place where a stream disappears underground

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







Name _____

Worksheet #1: Soluble Stuff

| | | |
|------------------|-----------|-------------|
| Word Bank | | |
| mixture | solution | soluble |
| dissolve | evaporate | non-soluble |

Directions

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

Material A **What is it?** _____

Describe what happens when mixed with water: _____

Will it filter out? _____

Material B **What is it?** _____

Describe what happens when mixed with water: _____

Will it filter out? _____

Material C **What is it?** _____

Describe what happens when mixed with water: _____

Will it filter out? _____





Name _____

Material D

What is it? _____

Describe what happens when mixed with water:

Will it filter out? _____

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

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

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

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

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

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

GROUP DISCUSSION

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

Do you think rocks are soluble?





Name _____

Worksheet #2: Vanishing Rocks

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

Caves in Indiana are formed in a rock

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

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

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

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

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

Material A What is it? _____

_____ Acid or _____ Base?

Material B What is it? _____

_____ Acid or _____ Base?

Material C What is it? _____

_____ Acid or _____ Base?

Material D What is it? _____

_____ Acid or _____ Base?





Name _____

Worksheet #3: Speleothem Garden

New Words
carbonic acid
saturated
organic matter

To make caves, we need two important ingredients: carbonate rocks, which are soluble, and an acid.

The main acid responsible for the formation of cave decorations is called **carbonic acid**. Carbonic acid reacts with limestone to deposit calcite formations called speleothems in caves.

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

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

Follow these directions to see how cave formations are created.

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

What happened?

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

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

Review Words

| | | |
|------------|-----------|------------|
| calcite | evaporate | speleothem |
| stalagmite | column | stalactite |





Name _____

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

How are they different?

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

_____ and

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

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





Name _____

Worksheet #4: Constructing Karst

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

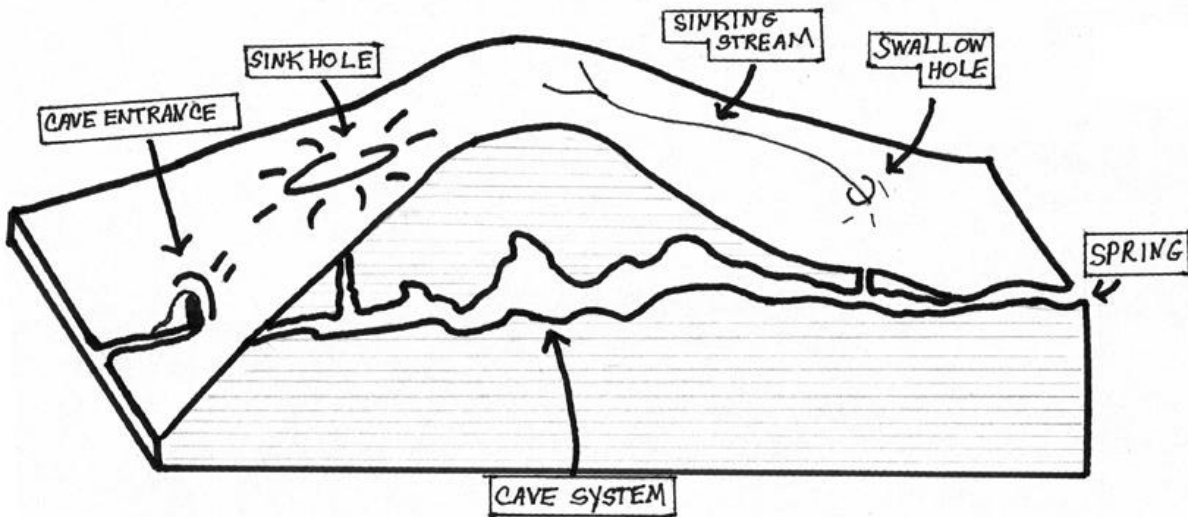
Indiana contains a large amount of karst topography. Study the karst diagram, then follow your teacher's instructions to build a karst landscape.

Important Words

Topography: the shape and physical features of the land.

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

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



Karst Features

Spring: an issuing of water from the ground

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

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

Swallow hole: the place where a surface stream disappears underground



