What is the National Natural Landmarks Program?
The National Natural Landmarks (NNL) Program recognizes and encourages the conservation of sites that contain outstanding biological and geological resources. NNL sites are designated by the Secretary of the Interior for their condition, illustrative character, rarity, diversity, and value to science and education. The designation occurs on lands of any ownership, both public and private.

Most NNLs are not part of the National Park System, rather they are in city, county or state parks, wildlife refuges, national forests, nature preserves, or even in someone’s backyard. NNL sites aren’t required to be open to the public; however, many sites do welcome visitation. The National Park Service administers the program and works cooperatively with landowners, managers, and partners to promote conservation and appreciation of our nation’s natural heritage. For more information see www.nps.gov/nnlandmarks.

National Natural Landmark Caves
Caves represent one of the outstanding geological features recognized at some NNL sites, including Wyandotte Cave in Indiana, Black Chasm Cave in California, Grand Caverns in Virginia, and Caverns of Sonora in Texas.

What exactly is a cave? A cave is a natural opening in the ground extending beyond the zone of light and large enough to permit the entry of a person. Occurring in various rock types and caused by different geological processes, caves range in size from single small rooms to interconnecting passages many miles long. The scientific study of caves is called speleology (from the Greek words spelaion for cave and logos for study).

There are four main type of caves, their formation depending on geology and local climate. Solution caves, like the Caverns of Sonora in Texas, are formed by slowly moving ground water that dissolves rock. Lava caves, like those found at Grants Lava Flow in New Mexico, form when the surface of a lava flow hardens while the molten lava drains out. Sea caves, such as those found on the Mona and Monita Islands of Puerto Rico, are formed by waves on rock-lined shores. Talus caves, similar to the large vents found at Ice Mountain in West Virginia, consist of open spaces among large rocks in talus piles at the base of cliffs or steep slopes. Learn more in the following pages.

Caves are not only geologic wonders but also provide habitat for an amazing collection of animals including fish, bats, salamanders, crayfish, spiders, crickets, and birds. For example, the Texas blind salamander can be found at Ezell’s Cave in Texas, and cave crayfish live in Shelta Cave in Alabama. Some of these organisms live their whole lives in caves, while others reside there only part of the time. Full-time cave dwellers have many adaptations to their dark, low-oxygen environments, including being blind or eyeless.

Please join us in celebrating “Earth as Inspiration” during Earth Science Week 2018 by exploring the beautiful underground worlds of caves in some of our National Natural Landmarks. Activities in the following pages help you explore cave formation and types, as well as the ways that some of the cool critters found in these caves can survive such tough conditions!
Let’s Explore the Different Types of Caves!

Solution Caves
When precipitation such as rainwater or snowmelt mixes with carbon dioxide from the air and from decaying plants in the soil, the result is carbonic acid. This acidic water flows through cracks in the earth’s surface and seeps into the rocks below. Once the acidic water reaches carbonate and sulfate rocks and other rocks that dissolve readily — such as limestone, marble, dolomite, and gypsum — it dissolves away the rock to create passageways, rooms, and speleothems, or cave formations. Most of the caves in the world — as well as the largest — are of this type.

Examples:
- Caverns of Sonora, TX (shown in both pictures here)
- Luray Caverns, VA
- Onondaga Cave, MO

Sea Caves
Sea or littoral caves are formed by the action of waves pounding against rocks that line the shores of oceans and larger lakes. These types of caves are evidence of the enormous power of waves and may be further modified and enlarged by wave-carried sand and gravel.

Example:
- Mona and Monito Islands, PR (pictured below)

Lava Caves
When fluid, molten lava flows out of the ground, it works its way downhill. Soon the surface of this lava stream cools and hardens into a crust. Although the outer crust is hard, the lava inside is still molten, and it continues to flow downhill. Once the molten lava has passed through, it leaves an empty tunnel called a lava cave, or more commonly, a lava tube.

Example:
- Grants Lava Flow, NM — located partially within El Malpais National Monument (shown in both pictures here)

Talus Caves
Talus caves consist of open spaces among large rocks and boulders in talus piles found at the bases of cliffs or steep slopes, including narrow canyons. Talus caves form when steep, narrow canyons fill with a jumbled mass of boulders from the cliffs above. Small, cave-like cold air vents at the base of steep talus slopes at Ice Mountain NNL in West Virginia are indicative of where talus caves can be found.

Example:
- Ice Mountain, WV (pictured)
Making Caves: How Solution Caves Form

An Activity for Grades K-12
Source: National Park Service

Caves form through a variety of natural processes depending on their local geology and climate. Flowing lava, melting ice, dissolving rock, and crashing waves are the major processes that form these wondrous environments. In this activity, students will observe a model of how the most common type of cave — solution caves — form.

Materials
Per student or small group:
• 4 ounces of modeling clay
• Sugar cubes (3-6 per cave)
• See-through bowl (cutting the top off a 2-liter bottle works well)
• Toothpick
• Spray bottle with warm water
• Lined paper
• Pen or pencil

Procedure
1. Organize the sugar cubes into a half pyramid along the bottom of the bowl, making sure the sugar is pressed up against one side of the bowl.
2. Seal the cubes tightly against the side of the bowl with the modeling clay, making sure there are no gaps. The clay layer should be about 1/8 inch thick. The sugar cubes that are pressed up against the glass should remain visible. This will act as a window into your cave.
3. Poke holes through the top of the clay with the toothpick, making sure that the holes go all the way through to the sugar cubes and are large enough for water to flow through them.
4. Spray the top of the cave with the warm water from the spray bottle. Continue spraying until the sugar cubes either are no longer in their original shape or have completely dissolved.
5. As the water seeps through the clay and into the sugar cubes, record your observations.
6. Draw a picture or describe what your cave looked like when finished.

Discussion
• What did the sugar cubes represent? What did the clay represent? Describe in your own words how this model simulated the formation of caves.
• How does observing the process of caves forming, or the caves and formations that result, inspire you?
• What words would you use to describe caves or how they form to someone who has never seen one?

Fort Stanton Cave, NM. An up-close look at some of the stalactites found in this cave. Credit: David Bunnell.

Project credits: Leo Acosta of NPS; Geoff Camphire, Brenna Tobler, Sequoyah McGee, and Adam Blankenbicker of AGI.
Adaptations of Cave Critters

An Activity for Grades K-12
Source: American Geosciences Institute

Caves with the National Natural Landmark (NNL) designation are some of the most fascinating of the thousands of caves around the world, and each one is unique. Caves’ special features are the product of various types of rock, their geologic setting, local climate, and time. This diversity in cave environments provides unique habitats for many different species of plants, animals, and other types of organisms. Each organism has developed specialized adaptations to survive in these cave environments.

Cave-dwelling animals, called Troglofauna, thrive in dark environments. Troglofauna are further subdivided into more categories according to how the cave is used. Troglobites (troglo: cave, and bios: life) live their whole lives in caves, while others spend just a part of their lives in caves and are called Trogloxene (troglo: cave, and xenos: guest).

Full-time cave dwellers have adaptations to their environments, such as being eyeless, blind, or colorless. Cave salamanders in NNL Marvel Cave in Missouri and cave crayfish in NNL Shelta Cave in Alabama are white and blind. These troglobites live in darkness. NNL Onondaga Cave in Missouri is home to grotto salamanders. When young, their brown and yellow flecked coloring blends with the environment near cave entrances where they live. As adults, they move deep into caves, becoming blind and losing most of their coloration. Mexican free-tailed bats sleep in caves like NNL Devil’s Sinkhole Natural Area in Texas all day, emerging at dusk. Hunting in darkness, they use echolocation to find insect prey.

In this activity, students will explore their creativity and critical thinking while they imagine a cave environment and create an organism that lives in their cave. Their cave will be one of the types mentioned in the preceding pages, but their organisms will be of their own imagination.

Materials
• 2 sheets of blank paper
• Coloring utensils
• Computer with internet connection

Procedure
1. On one sheet of paper, create a cave setting. Before drawing, discuss geologic and environmental conditions of cave environments:
   • How do different types of caves — solution, lava, sea, talus — form?
   • What types of geologic features are found in each type of cave?
   • What is the climate of your cave — hot or cold, wet or dry?
   • How big is the cave?
   • How much water is in the cave? Does it flow? Or is it still?
   • How dark does the cave get?
   • Is the entrance large or small? A hole in the ground or on the side of a cliff or hill?

2. On another sheet of paper, create an organism that is adapted to live in that cave. Before drawing, discuss:
   • Is the organism an animal, plant, or bacteria? If an animal, is it a reptile, fish, mammal, or other?
   • How big is it?
   • How does it get its nutrients?
   • How does it defend itself?
   • How does it move?
   • How does it behave?

3. Describe to the members of the group or your class why your organism is well-suited to live in your cave. Consider:
   • What would happen to your caves or organisms if there was an environmental change? What if the temperature rose due to climate change? What if there were an earthquake, flood, or drought?
   • How does learning about the interesting traits and adaptations of cave critters inspire you?
   • What adaptations and traits do people have to allow them to survive in our environment?

Compare your cave and organism with those of other students.
Discuss:
• How would your organism survive — or not — in your classmate’s cave? What elements of that cave would be helpful or harmful to your organism?
• How would your organism and your classmate’s organism interact with each other? Would they likely eat each other, fight, or get along? Are they competitors?

Next Generation Science Standards Connections

<table>
<thead>
<tr>
<th>Crosscutting Concepts</th>
<th>Earth and Space Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause and effect</td>
<td>Asking questions and defining problems</td>
</tr>
<tr>
<td>Structure and function</td>
<td>Engaging in argument from evidence</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking questions and defining problems</td>
<td>Life Science:</td>
</tr>
<tr>
<td>Engaging in argument from evidence</td>
<td>• Interdependent relationships in ecosystems</td>
</tr>
<tr>
<td>Developing and using models</td>
<td>• Adaptation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Earth and Space Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Science:</td>
<td>Adaptation</td>
</tr>
<tr>
<td>• Interdependent relationships in ecosystems</td>
<td>Natural Selection</td>
</tr>
</tbody>
</table>

Bats emerge from the Devil’s Sinkhole cave in Texas. Credit: National Park Service