Mystery of Blacktail Canyon

Grades: 9-12         Prep Time: ~10 min          Lesson Time: ~65-70 minutes

WHAT STUDENTS DO: Explore a virtual field trip of the Grand Canyon.

Students will explore Grand Canyon, AZ using a virtual field trip (VFT). They will observe the rock record and what these rocks tell us about the life and environments of the past. Then they will apply investigation techniques to the search for life in the solar system.

NRC FRAMEWORK/NGSS CORE & COMPONENT QUESTIONS

HOW AND WHY IS EARTH CONSTANTLY CHANGING?

NGSS Core Question: ESS2: Earth’s Systems

Why do the continents move, and what causes earthquakes and volcanoes?

NGSS ESS2.B: Plate Tectonic and Large-Scale System Interactions

How do the properties and movement of water shape Earth’s surface and affect its systems?

NGSS ESS2.C: The Roles of Water in Earth’s Surface Processes

INSTRUCTIONAL OBJECTIVES (IO)

Students will be able to

IO1: Construct an explanation for why multiple missions are sent to a variety of locations on planetary bodies to investigate their geologic history and search for signatures of life.

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HOW CAN THERE BE SO MANY SIMILARITIES AMONG ORGANISMS YET SO MANY DIFFERENT KINDS OF PLANTS, ANIMALS, AND MICROORGANISMS?

HOW DOES THE BIODIVERSITY AFFECT HUMANS?

NGSS Core Question: LS4: Biological Evolution: Unity and Diversity

How does the environment influence populations of organisms over multiple generations?

NGSS LS4.C: Adaptation

What is biodiversity, how do humans affect it, and how does it affect humans?

NGSS LS4.D: Biodiversity and Humans
# 1.0 Materials

## Required Materials:

**Please supply:**

- Computer, Laptop, or Tablet – 1 per student
  - Supported Browsers: Chrome; Edge; Firefox; Safari

**Please Print:**

**From Student Guide**

- (A) Mars Mission Table – 1 per student
- (B) Tying Geology and Biology Together – 1 per student
- (C) Search for Missing Time – 1 per student
- (D) Missing Time on Mars Evaluation – 1 per student

## Optional Materials:

**From Teacher Guide**

- (E) Tying Geology and Biology Together (KEY)
- (F) Search for Missing Time (KEY)
- (G) Missing Time on Mars Evaluation (KEY)

**From Alignment Document**

- (N) “Mystery of Blacktail Canyon” Alignment Rubrics
2.0 Lesson Timeline

*Mystery of Blacktail Canyon*

**Lesson Timeline:**

Time:
- 65-70 minutes

Materials:
- Computer, Laptop, or Tablet
- Student Guide pages

5-E Inquiry Process:
- The arrow color represents the 5-E step students will be primarily engaging in for that class session

- **Engage**
  - Prediction
  - (10 min)

- **Explore**
  - Virtual Field Trip
  - (35 min)

- **Explain**
  - Geology/Biology Table
  - (10-15 min)

- **Elaborate**
  - Life & Earth Connections
  - Gale Crater
  - (5 min)

- **Evaluate**
  - Apply to Planetary Exploration
  - (5 min)
## 3.0 Vocabulary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cambrian Explosion</td>
<td>the sudden appearance of complex animal life in the fossil record</td>
</tr>
<tr>
<td>explanation</td>
<td>a logical description applying scientific information</td>
</tr>
<tr>
<td>fossil</td>
<td>the preserved remains or traces of past life</td>
</tr>
<tr>
<td>Great Unconformity</td>
<td>a regional unconformity representing a gap in geologic time of nearly 1.2 to 1.6 billion years</td>
</tr>
<tr>
<td>lander</td>
<td>a spacecraft designed to explore on the surface of a planet from a stationary position</td>
</tr>
<tr>
<td>mission</td>
<td>a spacecraft designed to explore space, seeking to answer scientific questions</td>
</tr>
<tr>
<td>observations</td>
<td>specific details recorded to describe an object or phenomenon</td>
</tr>
<tr>
<td>planetary body</td>
<td>a sphere moving in orbit around the Sun or a moon orbiting a planet</td>
</tr>
<tr>
<td>Precambrian</td>
<td>the earliest interval of time which represents 80-90% of Earth’s history and contains little evidence of life, most of which is simple</td>
</tr>
<tr>
<td>rover</td>
<td>a spacecraft designed to explore and travel on the surface of a planet</td>
</tr>
<tr>
<td>unconformity</td>
<td>a gap in the rock record caused by climate change or tectonic activity</td>
</tr>
</tbody>
</table>
4.0 Procedure

PREPARATION

A. Visit [https://infiniscope.org/lesson/mystery-blacktail-canyon/](https://infiniscope.org/lesson/mystery-blacktail-canyon/) for access to the digital learning experience, standards alignment documents, and additional resources.

B. Reserve computers, laptops, or tablets for Exploration Day.

C. PRINT THE FOLLOWING:
   - Student Recording Sheets (A-D) – 1 per student

ENGAGE (10 minutes)

Why So Many Missions?

A. Hand out *(A) Mars Mission Table*. Explain there have been many missions to Mars and other planetary bodies in the solar system. The table shows a list of every successful mission NASA has ever sent to Mars. Ask students to review and reflect on this mission list. Consider some possible explanations for why NASA sends so many missions to places such as Mars. They will create their list on the sheet.

B. Ask students to turn to their neighbor and share their lists. Circle the ones they have in common and put a star next to the one that is the most likely explanation for why NASA sends so many missions to places such as Mars.

C. When students have completed their lists, point out “there are many reasons for sending so many missions, but today we will be discovering just one of these reasons. To do this, we will need to connect our understandings of the life sciences to our understandings of the earth sciences.”

EXPLORE (~ 35 minutes)

Mystery of Blacktail Canyon Virtual Field Trip

A. Explain to the students that they will be taking a virtual field trip to the Grand Canyon to start connecting their understandings.

B. Hand out *(B) Tying Geology and Biology Together*. Students will complete box 1 and box 2 regarding the life science and earth science processes they discover from the VFT.

C. Hand out or assign computers and ask students to access the Mystery of Blacktail Canyon digital learning experience at [https://infiniscope.org/](https://infiniscope.org/) and choose “Explore” to launch the experience.

Teacher Tip: If you would like to analyze student interactions in this activity, you can sign up to join the Infiniscope Teaching Network ([https://infiniscope.org/join/](https://infiniscope.org/join/)) and enroll your class into the activity. By enrolling, you will gain access to the analytics of the
activity by student to see how students progressed through the activity. You also have the ability to adopt the activity and adapt it to the specific needs of your classroom, school, or community.

**EXPLAIN** (~ 10-15 minutes)

**Tying Geology and Biology Together**

A. When students have completed the VFT, ask them to complete box 3 and box 4 on **(B) Tying Geology and Biology Together** to help them process the connections between life science and earth science.

B. As a class or in pairs/groups, ask students to discuss what they found. What are the connections between life science and earth science in this example?

C. See **(E) Tying Geology and Biology Together (KEY)** for guidance if necessary.

**ELABORATE** (~ 5 minutes)

**Search for Missing Time**

A. At this point, students understand that the Great Unconformity represents a huge chunk of missing time in the rock record. But the question remains, how do scientists fill in these gaps in time?

B. Hand out **(C) Search for Missing Time** or discuss the details on the sheet with the students, while showing the diagram on a projector. Ask student’s to work together with a partner to complete this sheet.

C. See **(F) Search for Missing Time (KEY)** for guidance if necessary.

**EVALUATE** (~ 5 minutes)

**Evaluate the Search for Missing Time on Mars**

A. Hand out **(D) Missing Time on Mars Evaluation**.

B. Students should be able to tie all the elements together to conclude why NASA sends so many missions to planetary bodies such as Mars. Our search for life needs a complete rock record. If layers (time) are missing, we look in other locations for the missing time. Sometimes this requires being across the planet, just like the example of Australia filling in the missing gaps of time from the Grand Canyon. However, when we talk about other planetary bodies, a rover can’t get across the body. Separate rovers/landers are sent to different locations to fill in another gap in time.

**5.0 Evaluation/Assessment**

Use the **(N) Mystery of Blacktail Canyon Alignment Rubric** as a summative assessment. The rubric evaluates the activities using the Learning Outcomes identified in the Alignment Documents for the activity.
6.0 Extensions

1. Explore these VFT’s of Western Australia:
   a. Marble Bar
   b. Karijini Gorge
   c. Nilpena
   d. Dresser Formation
   e. Knossos Locality
MYSTERY OF BLACKTAIL CANYON

(A) Mars Mission Table

Name: _____________________________________

Instructions:
Below is a table containing every successful mission the United States has sent to Mars in the history of space exploration. The length of this list may be surprising. In fact, most people are surprised to see such a large list of missions to a single planet. Take a few minutes to review and reflect on this list. Consider some possible explanations for why NASA sends so many missions to places such as Mars. List your reasons in the space below.

<table>
<thead>
<tr>
<th>Launch Date</th>
<th>Mission Name</th>
<th>Mission Type</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td>Mariner 4</td>
<td>Flyby</td>
<td>Returned 21 images</td>
</tr>
<tr>
<td>1969</td>
<td>Mariner 6</td>
<td>Flyby</td>
<td>Returned 75 images</td>
</tr>
<tr>
<td>1969</td>
<td>Mariner 7</td>
<td>Flyby</td>
<td>Returned 126 images</td>
</tr>
<tr>
<td>1971</td>
<td>Mariner 9</td>
<td>Orbiter</td>
<td>First spacecraft to successfully orbit Mars. Returned 7,329 images</td>
</tr>
<tr>
<td>1975</td>
<td>Viking 1</td>
<td>Orbiter / Lander</td>
<td>Located landing site for Lander and first successful landing on Mars</td>
</tr>
<tr>
<td>1975</td>
<td>Viking 2</td>
<td>Orbiter / Lander</td>
<td>Returned 16,000 images and extensive atmospheric data and soil experiments</td>
</tr>
<tr>
<td>1992</td>
<td>Mars Global Surveyor</td>
<td>Orbiter</td>
<td>More images than all previous Mars missions combined</td>
</tr>
<tr>
<td>1996</td>
<td>Mars Pathfinder/Sojourner</td>
<td>Lander / Rover</td>
<td>Technology experiment lasting 5 times longer than warranty</td>
</tr>
<tr>
<td>2001</td>
<td>Mars Odyssey</td>
<td>Orbiter</td>
<td>High resolution images of Mars</td>
</tr>
<tr>
<td>2003</td>
<td>Mars Exploration Rover – Spirit</td>
<td>Rover</td>
<td>Operating lifetime of more than 15 times original warranty</td>
</tr>
<tr>
<td>2003</td>
<td>Mars Exploration Rover – Opportunity</td>
<td>Rover</td>
<td>Operating lifetime of more than 15 times original warranty</td>
</tr>
<tr>
<td>2005</td>
<td>Mars Reconnaissance Orbiter</td>
<td>Orbiter</td>
<td>Returned more than 26 terabits of data (more than all other Mars missions combined)</td>
</tr>
<tr>
<td>2007</td>
<td>Phoenix Mars Lander</td>
<td>Lander</td>
<td>Returned more than 25 gigabits of data</td>
</tr>
<tr>
<td>2011</td>
<td>Mars Science Laboratory</td>
<td>Rover</td>
<td>Exploring Mars’ habitability</td>
</tr>
<tr>
<td>2013</td>
<td>Mars Atmosphere and Volatile Evolution</td>
<td>Orbiter</td>
<td>Studying the Martian atmosphere</td>
</tr>
</tbody>
</table>

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Last edited: April 25, 2018
During your exploration of the Mystery of Blacktail Canyon virtual field trip, Dr. Karl Karlstrom and Dr. Steve Semken discussed two key events: the Great Unconformity (a geologic concept) and the Cambrian Explosion (a biologic concept). Let's see if we can tie these two concepts together.

**Biology**

1. Describe the Cambrian Explosion.

2. Describe the biodiversity before, during, and after the Great Unconformity.

**Geology**

3. Describe the process in the formation of the Great Unconformity.

4. Describe the physical environment before, during, and after the Great Unconformity.
MYSTERY OF BLACKTAIL CANYON

(C) Search for Missing Time

Name: _______________________________

As you know, the Cambrian Explosion is a time when a lot of life appeared, but not just any life…complex life. Here in the Grand Canyon, we see a giant gap in geologic time (unconformity) prior to the Cambrian Explosion.

A great place on Earth to see Precambrian rocks exposed is in Western Australia. Geologists, Geochemists, and Paleobiologists go to places like these to see rocks missing in the early rock record.

Unconformities are common geologic features, so how do scientists fill in gaps in time such as these? They explore other regions! But these regions need to expose sedimentary rocks that contain fossils to fill in the missing stories of life. Recall, there are three types of rocks that can form.

You saw both metamorphic and sedimentary rocks in the Grand Canyon. Why do different rock types exist? Discuss this question with your neighbor and list one or two reasons.

____________________________________________________________________________
____________________________________________________________________________

Let’s apply this same concept to planetary exploration. If scientists were to identify an unconformity in rock layers in an image taken by a rover or a lander on another planet, what would they need to do to fill in the gaps in geologic time for that planet?

____________________________________________________________________________
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Name: _______________________________

Curiosity rover landed in Gale Crater, Mars in August of 2012. The image below is one of the first taken by the rover inside the crater. The area marked with white dots has been identified by scientists as an unconformity.

To continue the search for life on the red planet, what would NASA need to do to fill in this missing gap of time in Gale Crater?

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Based on what you’ve learned, what’s one reason NASA sends so many missions to planets such as Mars?

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

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MYSTERY OF BLACKTAIL CANYON

(E) Tying Geology and Biology Together (KEY)

During your exploration of the Mystery of Blacktail Canyon virtual field trip, Dr. Karl Karlstrom and Dr. Steve Semken discussed two key events: the Great Unconformity (a geologic concept) and the Cambrian Explosion (a biologic concept). Let’s see if we can tie these two concepts together.

**Biology**

1. Describe the Cambrian Explosion.
   
   A period of time when life was abundant. An explosion of new species appeared in the rock record.

2. Describe the Biodiversity before, during, and after the Great Unconformity.
   
   - No life recorded here before the unconformity
   - No data regarding life during the unconformity
   - Incredible biodiversity with the Cambrian Explosion after the unconformity

3. Describe the physical environment before, during, and after the Great Unconformity.
   
   - Before the unconformity, the environment may not have been hospitable to life, this rock has been changed (metamorphic)
   - During the unconformity, there is a great amount of erosion, possibly rivers, fast moving waters ripping layers away. Life may have existed here, but was not preserved.
   - After the unconformity, a water environment existed that was hospitable to life.

**Geology**

1. Describe the process in the formation of the Great Unconformity.
   
   - Elves Chasm Gneiss is formed
   - The crust was uplifted, exposing the gneiss to erosion
   - Sand and gravel is deposited on top of the gneiss
   - Layers upon layers form and compact
   - Colorado Plateau is uplifted
   - Colorado River carves the Grand Canyon exposing the unconformity and sedimentary layers above it

   1.1. No data regarding life during the unconformity
   1.2. Incredible biodiversity with the Cambrian Explosion after the unconformity

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MYSTERY OF BLACKTAIL CANYON

(F) Search for Missing Time (KEY)

As you know, the Cambrian Explosion is a time when a lot of life appeared, but not just any life…complex life. Here in the Grand Canyon, we see a giant gap in geologic time (unconformity) prior to the Cambrian Explosion.

A great place on Earth to see Precambrian rocks exposed is in Western Australia. Geologists, Geochemists, and Paleobiologists go to places like these to see rocks missing in the early rock record.

Unconformities are common geologic features, so how do scientists fill in gaps in time such as these? They explore other regions! But these regions need to expose sedimentary rocks that contain fossils to fill in the missing stories of life. Recall, there are three types of rocks that can form.

You saw both metamorphic and sedimentary rocks in the Grand Canyon. Why do different rock types exist? Discuss this question with your neighbor and list one or two reasons.

Plate tectonics and erosion/deposition are responsible for the variety of rock types.

Let’s apply this same concept to planetary exploration. If scientists were to identify an unconformity in rock layers in an image taken by a rover or a lander on another planet, what would they need to do to fill in the gaps in geologic time for that planet?

Search other locations on the planet using rovers or landers.
Curiosity rover landed in Gale Crater, Mars in August of 2012. The image below is one of the first taken by the rover inside the crater. The area marked with white dots has been identified by scientists as an unconformity.

To continue the search for life on the red planet, what would NASA need to do to fill in this missing gap of time in Gale Crater?

To fill the gaps, they need to search other areas of the planet or possibly even other areas of this same crater.

Based on what you’ve learned, what’s one reason NASA sends so many missions to planets such as Mars?

To search other areas of the planet, other missions are needed. A rover is not able to travel to the other side of the planet, so new rovers or landers must be sent to search for these missing segments of time and hopefully life!