

CENTRAL QUESTION: What happened at Cleveland-Lloyd Dinosaur Quarry?

TIME: 90-120 minutes

OVERVIEW:

- **SECTION 1** (15 minutes)
What can we learn from the fossil record?
- **SECTION 2** (30 minutes)
How can disruptions to an ecosystem lead to shifts in a population?
- **SECTION 3** (30 minutes)
How can evaluating evidence help us construct an argument?
- **SECTION 4** (15-45 minutes)
What can we learn from communicating our arguments?

MATERIALS:

- One computer per two students
- One computer with the ability to broadcast material onto a screen visible by the entire class
- Printed *Research Assistant Notebooks* for students to record notes
- White board or other surface for teacher to use while facilitating class discussions
- Additional resources:
 - *Student Learning Assessment Tool*
 - *Student Rubric for Presenting Arguments*
 - *Student Rubric for Assessing Learning Outcomes*

GETTING STARTED

Before class...

- Review this lesson plan, making notes on standards and/or skills you would like to focus on with your students. (**Hint:** Review the documents entitled *Curriculum Alignment* and the *Student Learning Assessment Tool* for ideas on skills and alignments that best support this investigation.)
- Review the following recommended strategies for optimizing student learning outcomes.
 - Working in pairs ensures that every student has the opportunity to share their ideas. As students progress through the investigation, you may want to combine pairs of students into small groups to provide more practice sharing and responding to the ideas of their peers.
 - Build a shared vocabulary for the learning tasks by identifying target vocabulary beforehand and encouraging students to use these words often. Model correct usage if needed.
 - Think about places you can activate prior knowledge by prompting students to relate new concepts to a familiar context.
 - Think about how to integrate the *Research Quest* investigations with other curriculum-aligned activities.
 - Create and engage student interest in the program by expressing your enthusiasm and/or describing your personal interest in this investigation. You may also want to emphasize that students will be working with authentic materials on research questions that scientists actually address in their work.
 - Introduce students to sentence stems that reinforce flexible thinking and help students verbalize their thought processes:
 - “I see...”
 - “I think...”
 - “I wonder...”

In class...

- Provide a brief overview of the lesson to the class.
- Introduce the objectives the class will be focusing on today.
- Provide each student with a copy of the *Research Assistant Notebook* (RAN).
- Navigate to www.researchquest.org and login using the email address and password you used to create your *Research Quest* account. Then, navigate to the investigations tab.
- Locate this investigation on that page - far right - and click on the orange button with the text that reads, “Student Login Information,” located below the name and thumbnail for this investigation. The student URL and your unique student access code will appear on the screen.
- Arrange students into pairs, one pair per computer. Instruct them to navigate to the following URL shown on the “Student Login Information” page, and enter the student access code found on this same page: www.researchquest.org/student/. It is important you have students use this particular URL and access code to get into the investigations. This allows you to keep your administrative account free of student activity.
- Students will find themselves on a landing page for the investigation that includes two optional videos. Watching the videos allows time for other students to get logged in and also provides additional background information about NHMU paleontologist Carrie Levitt and the mysterious Cleveland-Lloyd Dinosaur Quarry- the subject of these *Research Quest* investigations.
- Once logged in, students will be on the landing page for this investigation. They should watch the two videos on this page before they start the investigation. This will give them necessary background information.

SECTION 1: WHAT CAN WE LEARN FROM THE FOSSIL RECORD? (15 minutes)**OVERVIEW**

Students will examine the interactive quarry map from Cleveland-Lloyd Dinosaur Quarry. They will record their observations of this fossil record and document any questions or ideas they may have during their examination of the map.

ASSESSMENT

In this section, the instructor may find it useful to focus on the following critical thinking skills, defined in more detail in the *Student Learning Assessment Tool* located under the “Teacher Support” tab of the website:

- **Observation:** Make detailed, sense-based observations that discriminate between objects.
- **Problem Finding:** Propose a relevant idea and articulate the need for information and/or evidence to evaluate the idea.
- **Flexible Thinking:** Keep mind open to multiple ideas until all data is evaluated.

STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 1 <ul style="list-style-type: none"> Students watch the video on Step 1 of the website (1:32 minutes). 	<ul style="list-style-type: none"> Direct students' attention to the following before beginning the video: <i>Carrie is going to talk about the first task. Listen for what the task is and how to accomplish it.</i>
STEP 2 <ul style="list-style-type: none"> Students make qualitative and quantitative observations of the fossil record at Cleveland-Lloyd Dinosaur Quarry. Students ask questions that can be answered through scientific investigation, recording their thinking on page one of the <i>Research Assistant Notebook (RAN)</i>. <p><i>RESEARCH ASSISTANT NOTEBOOK (RAN): page 1</i></p>	<ul style="list-style-type: none"> Have a brief class discussion about the limitations of the model of the quarry map. Specifically, you might ask students to explain what data they think they could get from the map, and what data they could not get. Get a baseline reading of students' observation skills using the <i>Student Learning Assessment Tool</i>. Prompt students to look for patterns in the quarry map that might imply interaction among the organisms represented (such as proportion of carnivore/theropods to herbivore/sauropod/ornithischians), or possible evidence of the effects of natural forces and phenomenon. As students complete the first task, encourage small group conversations that draw out inferences with open-ended questions such as the following: <ul style="list-style-type: none"> – “What makes you think...?” – “What else could this mean?”

SECTION 1: WHAT CAN WE LEARN FROM THE FOSSIL RECORD? (Continued)

STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
REFLECT <ul style="list-style-type: none"> In pairs, students answer three reflection questions presented within the <i>Research Quest</i> website. 	<ul style="list-style-type: none"> You can view your students' responses under the "My Account" tab when logged into the <i>Research Quest</i> website. Note: If students' reflections are consistent with Carrie's they will be prompted to move on to the next step. If they are mostly different, they will be prompted to go back and figure out how to develop more detailed observations of the quarry map.

SECTION 2: HOW CAN DISRUPTIONS IN AN ECOSYSTEM LEAD TO SHIFTS IN POPULATIONS?*(30 minutes)***OVERVIEW**

Students will analyze and interpret field notes from Cleveland-Lloyd Dinosaur Quarry using background about the fossil record, geology and sediment, modern animal interactions, and natural disasters to guide their inferences about interactions between organisms within the Jurassic-era ecosystem of this site.

ASSESSMENT

In this section, the instructor may find it useful to focus on the following critical thinking skills, defined in more detail in the *Student Learning Assessment Tool* located under the "Teacher Support" tab of the website:

- Interpretations:** Make inferences and interpretations that clearly articulate a link between the evidence and the interpretation.
- Connections:** Use multiple materials and objects; use evidence from one source to examine related data in another source.
- Problem Finding:** Propose a relevant idea and articulate the need for information and/or evidence to evaluate the idea.
- Flexible Thinking:** Keep mind open to multiple ideas until all data is evaluated.

STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 3 <ul style="list-style-type: none"> Students watch the video on Step 3 of the website (1:58 minutes). 	<ul style="list-style-type: none"> Direct students' attention to the following before beginning the video: <i>Carrie is going to talk about the interdependent relationships that existed in this area millions of years ago. Pay close attention to how understanding the fossil record, geology, modern animal interactions, and natural disasters can help you construct an explanation for what may have happened at Cleveland-Lloyd Dinosaur Quarry.</i>

SECTION 2: HOW CAN DISRUPTIONS IN AN ECOSYSTEM LEAD TO SHIFTS IN POPULATIONS? (Continued)**STUDENT ACTION****TIPS FOR SUPPORTING CRITICAL THINKING****STEP 4**

- In pairs, students read through and discuss background information and field notes from Cleveland-Lloyd Dinosaur Quarry. Students can keep track of useful information and analysis using pages two through four in the RAN.

RAN: pages 2-4

- Students next read about modern examples of mass animal death assemblages and compare and contrast what they know about Cleveland-Lloyd Dinosaur Quarry with these examples. Page five in the RAN is designed to record and analyze their ideas.

RAN: page 5

- Note: There is a large amount of information presented in this section; please adapt instructions for this section to meet the needs of your students. One possible adaptation is to assign groups different sections of the content to become “experts” on and then instruct them to share their thoughts with peers. You may also find it helpful to do the first section, “Skeletal Data,” as a class.
- Prompt students to think about the field notes in the context of an ancient ecosystem and reinforce the concept of stability and change by drawing on previous knowledge and experiences familiar to the students. Possible discussion points include the following:
 - *Assuming natural laws operate today as in the past, what can we infer about the ecosystem of Cleveland-Lloyd Dinosaur Quarry?*
 - *What can happen if an ecosystem is out of balance?*
 - *What events or forces might push an ecosystem out of balance?*
- Evaluate students on the critical thinking skills you are targeting using the *Student Learning Assessment Tool* as a guide.

SECTION 3: HOW CAN EVALUATING EVIDENCE HELP US CONSTRUCT AN ARGUMENT? (30 minutes)**OVERVIEW**

Students will construct two different explanations for what may have happened at Cleveland-Lloyd Dinosaur Quarry based on the inferences they have made using evidence from the quarry map, field notes, modern examples, and their own prior knowledge. Then, students will analyze and evaluate their evidence to determine which explanation is best supported by evidence.

ASSESSMENT

In this section, the instructor may find it useful to focus on the following critical thinking skills, defined in more detail in the *Student Learning Assessment Tool* located under the “Teacher Support” tab of the website:

- **Evaluations:** Evaluates ideas or hypotheses using multiple pieces of evidence and/or considers the strength of evidence when evaluating an idea/hypothesis.
- **Flexible Thinking:** Keeps mind open to multiple ideas until all data is evaluated.

SECTION 3: HOW CAN EVALUATING EVIDENCE HELP US CONSTRUCT AN ARGUMENT? (Continued)

STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 5 <ul style="list-style-type: none"> Students watch the video on Step 5 of the website (3:19 minutes). 	<ul style="list-style-type: none"> Direct students' attention to the following before beginning the video: <i>Carrie is going to discuss the three types of evidence; strong, weak, and disconfirming. Pay especially close attention to how she evaluates pieces of evidence.</i>
REFLECT <ul style="list-style-type: none"> In pairs, students answer three reflection questions presented within the <i>Research Quest</i> website. 	<ul style="list-style-type: none"> You can view your students' responses under the "My Account" tab when logged into the <i>Research Quest</i> website. Note: If students' reflections are consistent with Carrie's they will be prompted to move on to the next step. If they are mostly different, they will be prompted to go back to take another look at their evidence.
STEP 6 <ul style="list-style-type: none"> Students complete page six in the RAN, constructing explanations, analyzing their notes for evidence, and evaluating the evidence to determine which argument is the strongest. <p><i>RAN: Page 6</i></p>	<ul style="list-style-type: none"> Ask students to model the process of deciding whether evidence is strong, weak, or disconfirming. Clarify as needed. It may be helpful to note here that some evidence does not prove or disprove a specific explanation. While monitoring student conversations, prompt students to draw out their inferences with open-ended questions such as these: <ul style="list-style-type: none"> – "What makes you think....?" – "What else could this mean?" Note: This may be a good time to introduce the Student Rubric for Presenting of Arguments to guide students as they develop their explanation and identify evidence.

SECTION 4: WHAT HAPPENED AT CLEVELAND-LLOYD DINOSAUR QUARRY? (15-45 minutes)**OVERVIEW**

Students will engage in argument from evidence as they communicate their explanation and reasoning, responding respectfully to criticism and questions from peers. Students will also listen and respectfully communicate questions and critiques of peers' arguments.

ASSESSMENT

In this section, the instructor may find it useful to focus on the following critical thinking skills, defined in more detail in the *Student Learning Assessment Tool* located under the "Teacher Support" tab of the website:

- Evaluations:** Evaluates ideas or hypotheses using multiple pieces of evidence and/or considers the strength of evidence when evaluating an idea/hypothesis.
- Flexible Thinking:** Keep mind open to multiple ideas until all data is evaluated.

SECTION 4: WHAT HAPPENED AT CLEVELAND-LLOYD DINOSAUR QUARRY? (Continued)

STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
<p>STEP 7</p> <ul style="list-style-type: none"> Students review the tips for communicating their arguments with their peers and prepare to present in small groups. Students may use the <i>Student Rubric for Presenting Arguments</i> to evaluate the strength of their argument and improve on it prior to presenting. Students may also find page seven in the RAN useful to help organize their argument. <p><i>RAN: page 7</i></p>	<ul style="list-style-type: none"> Tips for communicating arguments are on Step 7 of the website. Use these to facilitate conversation among groups and/or the whole class. Distribute the <i>Student Rubric for Presenting Arguments</i> if you haven't already. Students can assess the strength of their group's argument and make changes to strengthen it as needed.
<p>PRESENT</p> <ul style="list-style-type: none"> Students present their argument to their peers. This includes generating, receiving, and responding to respectful critiques and clarifying questions. Students use the <i>Student Rubric for Presenting Arguments</i> to evaluate the strength of their peers' arguments. Students should use this document to help identify areas of weakness in their peers' presentations, responding with clarifying questions and respectful critiques. 	<ul style="list-style-type: none"> There are many forms that student presentations could take. Choose a method that you prefer. Ask open-ended questions that draw out inferences. Some students may benefit from using sentence stems to help facilitate discussion about their ideas. Evaluate students on the critical thinking skills you are targeting in this section using the <i>Student Learning Assessment Tool</i> as a guide. Encourage students to actively listen and respond to each others' presentations. Note: Many students may at first be uncomfortable constructing and responding to helpful critiques and questions. Emphasize that engaging in argument from evidence in science is not about having the "correct" answer, it is about identifying relevant evidence, evaluating that evidence, and then communicating your thinking to others.
<p>STEP 8</p> <ul style="list-style-type: none"> In pairs, students fill out the web form on Step 8 of the website and press "submit" to share their group's argument with Carrie. 	<ul style="list-style-type: none"> Note: This step is optional. However, if students do submit this form you will be able to access their responses in your admin dashboard on the <i>Research Quest</i> website.

SECTION 4: WHAT HAPPENED AT CLEVELAND-LLOYD DINOSAUR QUARRY? (Continued)**STUDENT ACTION****TIPS FOR SUPPORTING CRITICAL THINKING****STEP 9**

- In pairs or small groups, students watch the videos on Step 9 of the website, using the *Student Rubric for Presenting Arguments* to evaluate the strength of each explanation.
- In groups or as a class, students engage in a brief discussion about which of the arguments that Carrie presented is the strongest.

- Direct students' attention to the following before beginning the videos:

Carrie is going to present the leading arguments for what happened at Cleveland-Lloyd Dinosaur Quarry. As you watch each video, evaluate the strength of each explanation and associated evidence. Use the Student Rubric for Presenting Arguments to determine which argument seems to be the strongest.

STEP 10

- Students may complete additional extension activities.

- Optional extension activities are provided on the website to take student learning a step further.
- The *Student Rubric for Assessing Learning Outcomes* is located in the support materials for each investigation. Using this rubric, students can reflect on the critical thinking skills they developed and practiced during this investigation, and think about ways they can continue to use these skills in the future.
- Reinforce critical thinking skills, vocabulary, and other target behavior during curriculum-aligned activities.