CENTRAL QUESTION: How is energy transfer and matter cycling affected in a changing ecosystem?

TIME: 2.5-3 hours

OVERVIEW:

- **SECTION 1: GATHER** (20 minutes)
  What does normal look like in this forest?
- **SECTION 2: ANALYZE** (60 minutes)
  How does energy flow in this ecosystem?
- **SECTION 3: INTERPRET** (25 minutes)
  How does energy flow change as lodgepole pines continue to die off?
- **SECTION 4: COMMUNICATE** (45 minutes)
  How will the loss of lodgepole pines affect the energy producers in this ecosystem?

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***

STANDARDS ALIGNMENT:

Utah SEEd Standard

- **6.4.3** - Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems. Examples could include Utah ecosystems such as mountains, Great Salt Lake, wetlands, and deserts.

NGSS Standard

- **LS2-3** - Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

ELA Standards

- **Speaking & Listening Standard 5:** Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.
- **Reading: Informational Text 4:** Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings.

GETTING STARTED

This investigation provides support for teaching the content standards, along with the nature of science/how science is done, developing claims, working with evidence, and using reasoning skills. (**Hint:** Review the documents entitled *Curriculum Alignment* and the *Student Learning Assessment Tool* for other alignments and to assess learning with your students.)

Before class...

- Review this instructional guide and determine your student learning goals, which sections you want students to work on during each class period of the investigation, and the steps where your students will need guided instruction.
- 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 though 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 key vocabulary beforehand and encouraging students to use these words often. Model correct usage if needed.
        - **Key Vocabulary:** phenomenon, ecosystem, organism, montane, trophic level, photosynthesis, energy, simulator, producers, consumers, decomposers
    - 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 own work.
    - Introduce students to sentence stems that reinforce flexible thinking and help students verbalize their thought processes:
        - "I see..."
        - "I think..."
        - "I wonder..."

Set Up...

- Make copies of the Research Assistant Notebook (RAN) for each of your students, or use the PDF with your desired digital classroom platform (ie. Google Classroom, Canvas, etc).
- 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 "My Account" tab at the far right of the navigation bar. You will find your **Student Access Code**.
- Have your unique Student Access Code and URL link [www.researchquest.org/student/] ready for students. **It is important you have students use this particular URL and access code to get into the investigations for FERPA.**

In class...

- Introduce the daily objectives and provide a brief overview of the investigation to the class.
- Provide each student with a copy of the *Research Assistant Notebook* (RAN).
- Arrange students into pairs, one pair per computer. Instruct them to navigate to the URL [www.researchquest.org/student/] and enter your unique Student Access Code.
- Students will find themselves on a landing page with the option to go into one of two investigation modules. They should choose, "Change in the Uinta Mountains: Normal or Not?" Then, they should click on investigation #3 "How is Energy Transfer and Matter Cycling Affected in a Changing Ecosystem?"
- Once logged in, students will be on the introduction page for this investigation. They can read the overview and start at your direction.

SECTION 1: GATHER - WHAT DOES NORMAL LOOK LIKE IN THIS FOREST? *(20 minutes)*

OVERVIEW

Students will use a food web model to gather data and classify which the roles (producer, consumer, and decomposer) each organism plays in this montane ecosystem.

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* which can be found through the "Teacher Support" tab and by clicking on the *How is Energy Transfer and Matter Cycling Affected in a Changing Ecosystem?* link.

- **Observation:** Make detailed, sense-based observations to classify organisms.
- **Connections:** Use a food web model to classify organisms by their trophic roles in this montane ecosystem.

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 1 *(5 minutes)*	• Watch the video on Step 1 of the investigation. (3:03 min.) • Listen for the key questions that will help guide your investigation.	• Direct students' attention to the following before beginning the video: *In this video you'll be introduced to the phenomenon we'll be investigating today and receive instructions for the first part of your investigation. Be sure to listen for key questions that will guide your work to gather data and evidence.* • **Key Vocabulary:** phenomenon
STEP 2 *(15 minutes)*	• Use the food web model to sort organisms into their trophic levels. • Based on the food web activity, what are each of these trophic levels? Write your definition in the circles and draw a arrows between them to describe their relationship with each other. Use your *Research Assistant Notebook* Step 2. *Research Assistant Notebook (RAN): page 1*	• Students will develop a model to visualize how organisms are arranged by trophic levels. They will use this model to analyze energy flow in the next step. • Classify a few of the organisms as a class. Encourage students to click on organisms to locate information about their diets which can help them classify. • Tap into students' previous knowledge to discuss what it means to be a producer, consumer, and decomposer. It might be helpful to review the term trophic levels or trophic cascade. • *Note: Students will be able to check their answers in Step 3.* • **Key Vocabulary:** trophic level, montane ecosystem

SECTION 2: ANALYZE - HOW DOES ENERGY FLOW IN THIS ECOSYSTEM? *(60 minutes)*

OVERVIEW

Students will analyze how energy flows between trophic levels; producer, consumer, and decomposers; by drawing arrows. Then, analyze Dr. Mitch's model, and answer questions based on a simulation that shows energy and matter moving through a simple ecosystem.

ASSESSMENT

- **Observation:** Make detailed, sense-based observations to classify organisms.
- **Connections:** Use a simulator to discern the ways in which energy and matter cycle in an ecosystem.
- **Comparisons**: Note similarities and differences within simulations to identify patterns in the flow of energy within an ecosystem.

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 3 *(15 minutes)*	• Review the information about "Energy Flow and Matter Cycling" then click "Next" when you're ready to get started.	• Student pairs should review the information about "Energy Flow and Matter Cycling" to check their model in Step 2, then click "Next" when they're ready to get started. • Note: Step 3 can be used as a tool to uncover any misconceptions and assess students' grasp of each of the three key trophic levels that exist in all ecosystems. This understanding is necessary in order to grapple with the larger question of what happens to energy transfer and matter cycling in a changing system. • **Key Vocabulary:** ecosystem, photosynthesis, producers, consumers, decomposers
STEP 4 *(5 minutes)*	• Work with your partner to add arrows to the trophic model to show how energy flows from trophic level to trophic level.	• Students discuss energy flow and draw their lines to show the energy flow across trophic levels for this ecosystem • **Key Vocabulary:** energy
STEP 5 *(15 minutes)*	**REFLECT** • Compare your model from Step 3 to Dr. Mitch's model. *a.* How was your model the same or different than Dr. Mitch's model? *b.* How did this model help you understand something new? (getting at how models help build new understandings) • Click on the arrows in Dr. Mitch's model to learn more about how energy flows through this ecosystem. • When you're done, you can download your model and then click "next" to move on to the next activity. *Research Assistant Notebook (RAN): page 1*	• Students should reflect on their models as they compare theirs to Dr. Mitch's model. • Students can work on the questions in their RAN in small groups or you can work on these as a class discussion. • Use this discussion to guide students in noting similarities and differences between their model and Mitch's model. Then, support them in sharing what they learned through these comparisons.

SECTION 2: ANALYZE - HOW DOES ENERGY FLOW IN THIS ECOSYSTEM? *(Continued)*

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 6 *(5 minutes)*	• Watch the video on Step 4 of the investigation (2:45).	• Direct students' attention to the following before beginning the video: *In this video you'll hear more about how energy transfers within a system. Listen for information that can help you analyze this phenomenon.*
STEP 7 *(20 minutes, Varies)*	• Use the simulator to explore how energy and matter moves between trophic levels and the environment. Which resources does a lodgepole pine tree need to survive? • Once you have explored energy flow in nature, select 2 factors and draw a scene or diagram that tells your own story of how energy and matter cycle in an ecosystem. *Research Assistant Notebook (RAN): page 2*	• Direct students to try multiple combinations of trophic levels and how they interact with each other. They could do it as a story (an animal pooping or dying would be the likely climax to the story). • After using the simulator to explore how energy and matter flow through trophic levels, support students to illustrate their understanding of these ideas (flow of energy through trophic levels) as a labeled model.

SECTION 3: INTERPRET - HOW DOES ENERGY FLOW CHANGE AS LODGEPOLE PINES CONTINUE TO DIE OFF? *(25 minutes)*

OVERVIEW

Students will use the current and future trophic models to reason about which organisms could best preserve the current flow of energy in this ecosystem. They'll interpret which organisms are more likely to fill in the gaps (energy and biomass space) left by lodgepole pines.

ASSESSMENT

- **Interpretations:** Make inferences that clearly articulate a link between the evidence and the interpretation.
- **Observation:** Make detailed, sense-based observations that discriminate between organisms.

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 8 *(5 minutes)*	• Watch the video on Step 8 of the investigation. (1:55 min.)	• Direct students' attention to the following before beginning the video: *In this video you'll hear about how energy flow can be disrupted if even a single population of organisms is removed from an ecosystem. Listen for information that can help you develop an explanation for why this happens.*
STEP 9 *(10 minutes)*	• Discuss with your partner how the decline of lodgepole pine trees may impact the energy flow between the trophic levels. Complete the model using the evidence you've collected. • Answer the reflection questions: What changed between the Current and Future trophic models? *Research Assistant Notebook (RAN): page 3*	• If needed, briefly review how to read graphs and charts. • This is a great opportunity assess student learning as they compare the models and discuss what is different and why.

SECTION 3: INTERPRET - HOW WILL THE LOSS OF LODGEPOLE PINES AFFECT THE ENERGY PRODUCERS IN THIS ECOSYSTEM? *(Continued)*

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 10 *(10 minutes)*	**REFLECT** • Summarize your predictions in your *Research Assistant Notebook or* type your explanation online and download it. *Research Assistant Notebook (RAN): page 3*	• Remind students about the simulator they used in the Analyze Section, if needed refer them back to their Research Assistant Notebook Steps 4-9. • Have students share their predictions with a partner, so their partner can provide feedback before the Communicate Section. • Note: Help your students make go deeper with their thinking and make connections to uncover the fact that while matter and energy will continue to flow through the system, the way they always do, they may do so through different organisms or through a reduction of biomass (less energy producing organisms in the ecosystem).

SECTION 4: COMMUNICATE - WHAT SPECIES ARE NEEDED TO MAINTAIN A CHANGED FOREST?

(45 minutes)

OVERVIEW

Students will communicate predictions that describe how energy and matter flow through this ecosystem and how that may change as lodgepole pines die off.

ASSESSMENT

- **Interpretations:** Develop a visual representation to describe this phenomena.

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 11 *(40 minutes, Varies)*	• Select an organism and draw a comic strip (short graphic story) or a write a diary entry that shows a day in the life of your organism. In that day, you could show how they took in matter and energy and how they expended it. As part of this comic you could include who benefits from their matter or energy.	• As part of this diary entry or comic, students could include who benefits from their matter or energy. This could be an extension of the model they drew in Step 7. • Note: This is just one suggestion for the communication section and is closely aligned with the ELA Speaking and Listening standards. Select a communication strategy that best aligns with your learning goals. Regardless of your approach we recommend using the "Student Rubric for Presenting Arguments" located under the "Teacher Support" tab of the website.
STEP 12 *(5 minutes)*	• Watch the video on Step 12 of the investigation. (2:31 min.)	• Direct students' attention to the following before beginning the video: *In this video Dr. Mitch explains his prediction for what he thinks could happen in the Uinta mountains in the future if lodgepole pines continue to die at their current rate. Listen for his prediction- is it similar to yours?*