Woolly Mammoth - Student Materials

Unit 6	Biology

Student Materials Table of Contents

Unit Opening

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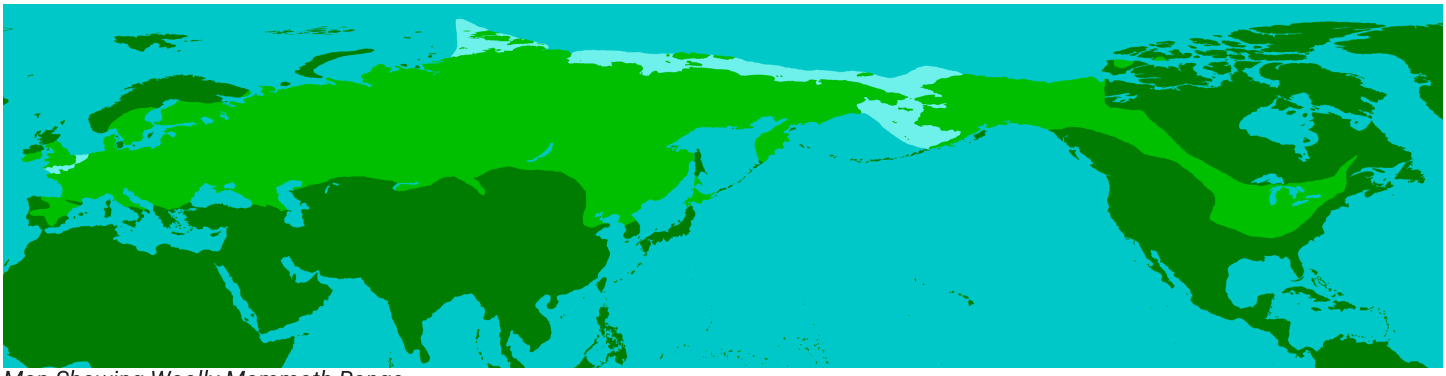
Student Name:	

Visual Texts

Visual #1

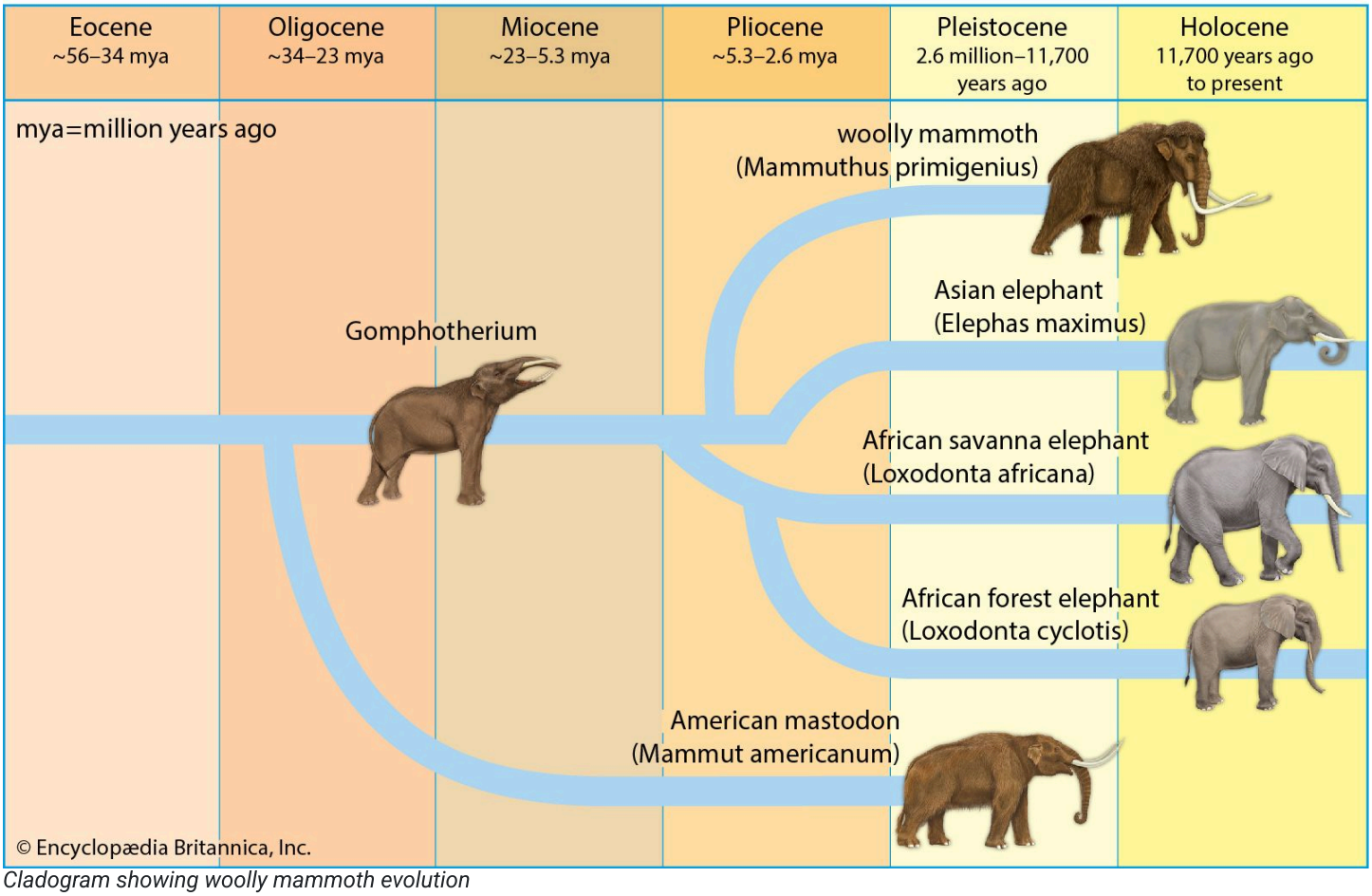


Map Showing Woolly Mammoth Range

Light green areas = where mammoths may have roamed
Dark green areas = where mammoths are not believed to have roamed
Light blue areas = ice-sheets the mammoths could have used to roam across continents

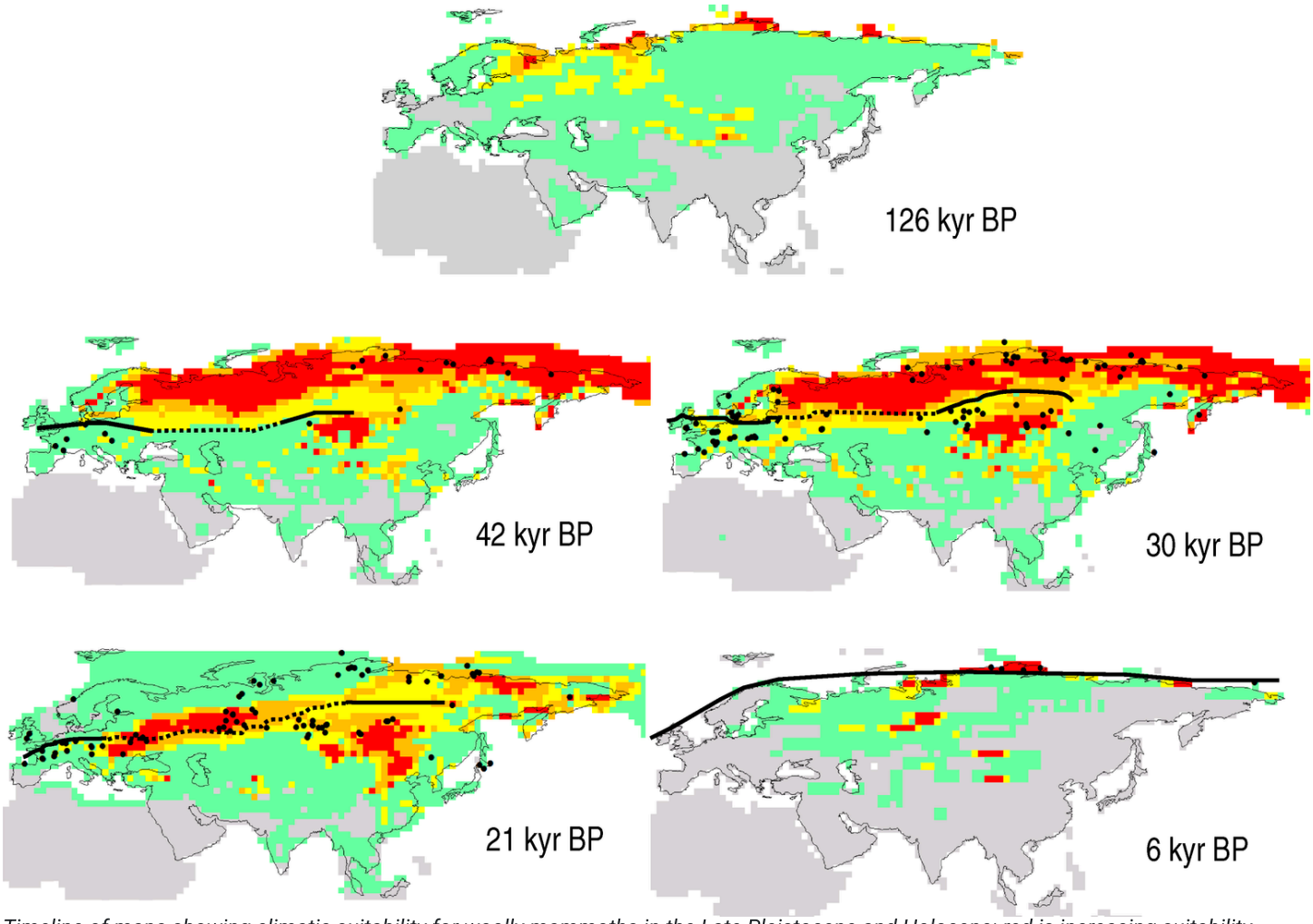
Visual #2

Evolution of modern elephants



Cladogram showing woolly mammoth evolution

Visual #3



Timeline of maps showing climatic suitability for woolly mammoths in the Late Pleistocene and Holocene: red is increasing suitability, green is decreasing suitability. Black points are records of mammoths; black lines are the northern limit of humans.

Kyr BP = thousands of years before the present

Tell the Story

Directions:

1. Silently read the visual text provided to you.
2. Circle or annotate three details that are most important to the phenomenon being described.
3. Share with your group. Each person should identify the details that they circled.
4. Discuss as a group, and determine the overall story. What is the phenomenon?

Extinction of the Woolly Mammoth

What is the overall story?

Important details our group surfaced (provide at least 5):

1. _____
2. _____
3. _____
4. _____
5. _____

Overall Story of the Phenomenon (based on group discussion):

Use the sentence starters:

- In the beginning ….
- After that ….
- By the end ….

Performance Task Organizer

Unit 6 Woolly Mammoth	Biology
Student Name:	

Initial Model

Why don't we see woolly mammoths anymore? Should we bring the woolly mammoth back from extinction?

In this performance task, you will develop a scientific model that represents the major causes behind the extinction of the woolly mammoth. You will then consider whether or not we should bring the woolly mammoth back from extinction and develop a scientific argument to defend your stance.

There is some disagreement among scientists about just how the woolly mammoth extinction occurred. While we can never know for sure what happened to them, we can use what we know about biology to evaluate different claims about the reason they died out.

Initial Claims

Directions

1. Brainstorm as many possible causes of the extinction of the woolly mammoth.
2. In your group, identify 5-6 of the most likely causes based on your knowledge of biology.
3. Each of the causes identified is a claim that you will investigate throughout the unit
4. Provide a brief rationale, based on scientific reasoning on why you choose each claim
5. Identify the empirical evidence you would need to support each claim.

Initial Extinction Model

Initial Prediction: Develop an initial model that represents what you think may have happened that caused the woolly mammoth to go extinct. Your initial model should include at least two different causes, and should illustrate the relationships between different parts of the system or between systems. It must also be based on evidence. It is ok to note evidence that you would need (but do not have yet), as this is an initial model.

Tuskless Elephant 5E - Extinction Model

Our Guiding Question: Was hunting by humans a cause of the extinction of the woolly mammoths?

1. Discuss the evidence from the learning sequence that supports the claim that humans were a cause of the woolly mammoth extinction. Be sure to discuss the nature and quality of the evidence presented (qualitative, quantitative, empirical, etc).

2. What further evidence would be helpful in supporting this claim?

3. Discuss the scientific reasoning and/or concepts from this learning sequence that you figured out and are informing the development of your model.

4. Develop a model that represents how humans may have caused the extinction. Be sure to include the relevant components of the system (or systems) and how those components and/or systems relate to one another at different scales.

Our Guiding Question: Was climate change a cause of the extinction of the woolly mammoths?

1. Discuss the evidence that supports the claim that climate change was a cause of the woolly mammoth extinction. Be sure to discuss the nature and quality of the evidence presented (qualitative, quantitative, empirical, etc).

2. What further evidence would be helpful in supporting this claim?

3. Discuss the scientific reasoning and/or concepts from this learning sequence that you figured out and are informing the development of your model.

4. Develop a model that represents how humans may have caused the extinction, based on your best understanding at this point in the unit. Be sure to include the relevant components of the system (or systems) and how those components and/or systems relate to one another at different scales.

Kelp Forest 5E - Extinction Model

Our Guiding Question: What was the cause(s) behind the extinction of the woolly mammoth? Did ecosystem instability or disruption play a role?

In this learning cycle, we learned about ecosystem stability. Discuss the evidence that supports the claim that ecosystem instability, disruptions to the ecosystem (or a related claim) was a cause of the woolly mammoth extinction. Be sure to discuss the nature and quality of the evidence presented (qualitative, quantitative, empirical, etc).

Discuss the scientific reasoning and/or concepts from this learning sequence that you figured out and are informing the development of your model.

What further evidence would be helpful in supporting this claim?

Return to your initial claims and earlier extinction models. If there are claims that you are still curious about (for example, the role disease may have played in the extinction) research and discuss these ideas below.

Develop a model, based on evidence and scientific reasoning, that represents what you think caused the woolly mammoth to go extinct. Your model can demonstrate how more than one factor (claim) contributed to the extinction of the woolly mammoth. Be sure to include the relevant components of the system (or systems) and how those components and/or systems relate to one another at different scales.

Passenger Pigeon 5E - Argument Evaluation

Our Guiding Question: How can we evaluate arguments around de-extinction as a solution to human-caused biodiversity loss?

In this instructional sequence, we evaluated an argument that bringing species back from extinction, like the passenger pigeon, is a viable solution to the human-caused biodiversity crisis. Investigating how the pigeon went extinct, and its role in the ecosystem helped in evaluating this argument.

Using your learning from this cycle, ideas developed and evidence presented throughout the unit, and *Woolly Mammoth Argument* to develop an initial evaluation of the argument behind bringing back the woolly mammoth from extinction.

In describing the **strengths** and **weaknesses** of the argument be sure to:

- Clearly identify the claims, evidence, and scientific reasoning behind the argument
- Evaluate the validity and reliability of the evidence – is there additional evidence that would support the argument?
- Assess the logic of the reasoning, based on your understanding of the scientific concepts – does the scientific reasoning sufficiently support the claim?

Final Task

Final Model

Based on all of the evidence and scientific reasoning generated in this unit, including your additional research, and the feedback provided by your peers and your teacher, generate a final model that represents the cause(s) behind the extinction of the woolly mammoth.

Final Argument Evaluation

Based on all of the evidence and scientific reasoning generated in this unit, including your additional research, and the feedback provided by your peers and your teacher, evaluate the argument that bringing back the woolly mammoth is a viable solution to the human-caused loss of biodiversity.

Final Model Rubric

Performance Task Model Rubric

Component	Level 4: Proficient	Level 3: Advancing	Level 2: Developing	Level 1: Beginning	
Representation of Components, Mechanisms, and Relationships in the Phenomenon **(The Science)**	Effectively and accurately represents at least **2** key factors/claims that caused the extinction of the mammoth and are based on evidence. Accurately demonstrates interactions between multiple parts of the system and/or between multiple organisms including cause and effect relationships Accurately demonstrates how the extinction of the mammoth affected other organisms or other parts of the system	Effectively and accurately represents at least **2** key factors/claims that caused the extinction of the mammoth and are based on evidence; May have minor inaccuracies Demonstrates interactions between multiple parts of the system and/or between multiple organisms including cause and effect relationships, may have minor inaccuracies Demonstrates how the extinction of the mammoth affected other organisms or other parts of the system. May have minor inaccuracies	Effectively and accurately represents at least **1** key factor/claim that caused the extinction of the mammoth and is based on evidence . Demonstrates at least 1 interaction between at least 1 part of the system or organism and another. May have minor inaccuracies Does not show how the extinction of the mammoth affected other organisms or parts of the system OR includes major inaccuracies.	Represents none of the key factors/claims that caused the extinction of the mammoth. Does not show interactions between any parts of the system or between organisms OR the interactions are inaccurate. Does not show how the extinction of the mammoth affected other organisms or parts of the system.	The student's response is missing, illegible, or irrelevant.

Decision making about visual representation (The Model)	Used proper symbols/notations to demonstrate phenomenon components, relationships, and mechanisms. The relationships between parts of the model are clear at different scales; Or contains legends/keys and written annotations to clarify the model.	Used some symbols/notations to demonstrate phenomenon components, relationships, and mechanisms. The relationships between parts of the model are mostly clear at different scales (with the use of legends/keys/annotations), with a few minor gaps.	Limited use of symbols/notations to demonstrate phenomenon components, relationships, and mechanisms. Demonstrates an attempt to clarify relationships in the model, but there are significant gaps in clarity and/or a lack of a legend/key/annotation.	No use of symbols/notations to demonstrate phenomenon components, relationships, and mechanisms. The relationships are not clear, and does not show an attempt at some legends/keys or written captions to clarify the model.	The student's response is missing, illegible, or irrelevant.
Using the model to develop a written explanation or prediction (The Explanation)	Individual written explanation includes the components, relationships and mechanisms represented in the model. Individual written explanation utilizes appropriate scientific terminology to develop an explanation of the phenomenon.	Individual written explanation includes the components, relationships and mechanisms represented in the model. Individual written explanation utilizes some appropriate scientific terminology to develop an explanation of the phenomenon than can be represented on the model.	Individual written explanation includes some of the components, relationships and mechanisms represented in the model. Individual written explanation has limited use of appropriate scientific terminology to develop an explanation of the phenomenon than can be represented on the model.	Explanation does not match the mechanism represented in the model. Individual written explanation has little to no use of appropriate scientific terminology to develop an explanation of the phenomenon than can be represented on the model.	The student's response is missing, illegible, or irrelevant.

Final Argument Evaluation Rubric

Component	Level 4: Proficient	Level 3: Advancing	Level 2: Developing	Level 1: Beginning	Not Evident
Strengths of the Argument Effectively and clearly outlines the strengths of the claim(s) evidence, and reasoning of the argument	An appropriate claim is accurately identified for the argument All of the given evidence is outlined and accurately described how it supports the claim The utility and accuracy of the given scientific reasoning of the argument is discussed	An appropriate claim is identified for the argument, but may have minor inaccuracies. All of the given evidence is outlined and accurately described how it supports the claim, but may have minor gaps or inaccuracies. The utility and accuracy of the given scientific reasoning of the argument is discussed, but with minor gaps or inaccuracies	An appropriate claim is identified for the argument, but may have major inaccuracies Some of the given evidence is identified and how it supports the claim The utility and accuracy of the given scientific reasoning of the argument is discussed, but with major gaps or inaccuracies	A claim is identified but is not appropriate for the argument. Some of the given evidence is identified but there is little to no attempt to describe how it supports the claim There is an attempt to discuss the scientific reasoning but does not include the utility or accuracy of the reasoning	No claim is identified for the argument No evidence is identified No scientific reasoning is discussed
Weaknesses of the Argument Effectively and clearly outlines the weaknesses of the claim(s), evidence, and reasoning of the argument	Identified appropriate and sufficient additional evidence that could be used to assess the validity and reliability of the given evidence and/or evaluate the claim The logic of the given scientific reasoning is clearly and accurately assessed, and if appropriate – additional scientific reasoning is provided	Identified appropriate additional evidence that could be used to assess the validity and reliability of the given evidence and/or evaluate the claim, but is not sufficient The logic of the given scientific reasoning is clearly and accurately assessed, with minor gaps or inaccuracies.	Identified additional evidence that is not sufficient or appropriate to assess the validity and reliability of the given evidence and/or evaluate the claim The logic of the given scientific reasoning is clearly and accurately assessed, with major gaps or inaccuracies.	There is an attempt to identify additional evidence. There is an attempt at assessing the given scientific reasoning	No attempt at identifying additional evidence No attempt as assessing the logic of the given scientific reasoning

Tuskless Elephants 5E

Unit 6 Woolly Mammoth	Biology
Student Name:	

Making Sense of the Analyzing Data on Tuskless Elephants Investigation

Use the graphic organizer below to record your ideas from the investigation.

See Things I see in the data collected	**Think** Ideas that this data makes me think about	**Wonder** Questions and wonderings I have about the data

Conclusion:

Based on your analysis, describe why the trait of tusklessness is increasing in some populations of female elephants.

Analyzing Data on Tuskless Elephants Investigation Rubric

Student Rubric - Analyzing Data on Tuskless Elephants Investigation

How did you do in the investigation?

	Student Self-Score Select one		
I know how this investigation connects to our current unit.	No - I need help.	Almost	Yes
I was able to contribute to the See-Think-Wonder and / or respond to the analysis questions.	No- I need help.	Almost	Yes
I used my time well in this investigation.	No	Mostly	Yes
I plan to come in for extra help to complete parts of the investigation or ask questions.	No		Yes

What other resources could you have used to get more out of this investigation?

- More time
- More resources
- More information
- More help from my partners
- More help from my teacher
- Other:

Partner Rubric - Analyzing Data on Tuskless Elephants Investigation

How did your partners do in the investigation?

Directions: Think back to how your partners participated in the lab. For each of the four categories, write the name(s) of your partner(s) in the appropriate box.

	Unsatisfactory	Pretty Good	Excellent
Contributions	Did not participate.	Did the minimum of what was required.	Provided useful ideas when participating in discussion.
Working with Others	Rarely listened to others. Disrupted or discouraged others' attempts to participate.	Usually listened to, shared with, and supported the efforts of others.	Listened to, shared with, and supported the efforts of others.
Time Management	Procrastinated, did not use school time or schedule provided to get work completed.	Mostly used time well and completed investigation on time.	Used time well to ensure things get done on time.

Tuskless Elephants Note Catcher

Directions:
As you watch the video, Selection for Tuskless Elephants , listen for information that will help you respond to the following questions.

1. The researcher states that elephants are important for the ecosystem, why are elephants especially important for the ecosystem in the park?

2. Explain why an abnormally large proportion of female elephants are tuskless in Gorongosa.

3. Explain why the percentage of tuskless elephants in Gorongosa National Park remained higher than normal, even after the war was over.

4. Using the cross-cutting concept of stability and change, explain why the elephant population is slowly increasing in Gorongosa park, and the number of tuskless elephants is decreasing (even though it continues to be higher than undisturbed populations).

5. The narrator mentioned that elephant populations are decreasing globally and that elephants are experiencing many impacts such as the loss of their tusks. Other than poaching, why do you think their populations are decreasing? What other impacts from human activities are they facing?

6. Why might we want to develop solutions to the negative impacts humans are causing to elephant populations?

Tuskless Elephant Text

Directions:

1. Return to the questions in the *Tuskless Elephants Note Catcher*
2. Read and annotate the text below to add new or additional information or questions
3. Use the following annotations as you read

    - Underline information that is relevant to questions in the note-catcher
    - **?** place a question mark next to any points that you have a question about
    - **!** place a exclamation point next to any points that are interesting

Poaching

Times of war can be especially challenging for both people and wildlife. The elephants and other large mammals in Gorongosa National Park suffered extreme poaching during the civil war in Mozambique. Poaching is when humans illegally kill wildlife in order to harvest their skins, tusks, meat, or other body parts. Poaching is one type of overexploitation, when humans use too much of a resource (in this case elephants) and it is no longer sustainable. Unfortunately, the illegal killing of elephants for their ivory tusks continues to be a problem for elephant populations everywhere because there is a high demand for ivory in many parts of the world. An estimated 100 African elephants are killed each day by poachers seeking ivory, meat and body parts. Even though ivory is banned or restricted in many countries, ivory traders can make a lot of money selling the tusks.

Human-Elephant Conflicts

Beyond poaching for ivory, elephants are threatened by their increasing interactions with humans. Less and less habitat is available for elephants because of increasing human populations. Therefore, elephants live closer to humans, often destroying crops and villages. When elephants raid crops, villagers lose their food and livelihoods, resulting in retaliatory killing of elephants.

On the other hand, elephant based tourism may benefit local communities if organized in a way to both minimize harm to elephants and maximize local profits. People from all over the world come to visit elephants in their natural habitat, because they are considered by many people to be a beautiful, charismatic, and interesting species. Elephants live a very long time, up to 70 years and display many unique traits such as mourning their dead and complex communication.

Elephants Role in the Ecosystem

African elephants are considered keystone species. They help increase biodiversity because they serve as ecosystem engineers, creating and maintaining habitats for other species. When forest elephants eat, they often pull up small trees and shrubs, creating a gap in the dense vegetation. These gaps allow new plants to grow and create pathways for other smaller animals to use. Elephants that live in the savanna, also eat small trees and shrubs that help keep the grasslands open. These grasslands then support many other types of animals like zebras and gazelles.

Wherever they live, elephants disperse seeds through their dung. They travel over far distances and then deposit their dung in new places. The seeds found in their dung then sprout and grow into new grasses and plants. Some species of plants rely solely on elephants to disperse their seeds. Additionally, elephants use their tusks to dig for water during droughts. The water holes they create are used by many different animals.

Changes in Elephant Populations

Globally, elephant numbers have dropped by 62% over the last decade, and they could be mostly extinct by the end of the next decade. Additionally, elephant populations are changing due to human actions. In many populations under heavy poaching pressure, fewer female elephants are being born with tusks. In other words, being tuskless has become an advantage in certain environments because of human poaching even though generally having tusks is an advantageous trait because of their use in digging and protection. Elephant behavior is also changing in some populations that have had negative interactions with humans. Some populations have become more active at night than in the day in order to avoid humans. Other populations use the habitat differently than they historically have, avoiding certain areas or over-using other locations.

Designing a Solution for Elephant Decline

Directions:
Design a solution that involves reducing the negative effects of human activities on the environment and biodiversity in Gorongosa National Park.

1. Develop a model that represents how humans are causing a problem, including the evidence you used to determine this cause-and-effect relationship. Be sure to include the relevant components of the system (or systems) and how those components and/or systems relate to one another at different scales.

2. Describe 1-2 criteria for a proposed solution. Briefly describe why your criteria should be prioritized in designing an effective solution.

3. Describe the scientific knowledge you are basing your proposed solution on.

4. Describe what evidence you are basing your proposal on, AND what evidence you would like to collect in order to refine or evaluate your solution.

5. Describe what tradeoffs you are considering as you develop your proposed solution.

6. Use the space below to describe or sketch out your proposed solution.

7. Describe how your proposed solution decreases the negative effects of human activity on the environment and biodiversity.

Peer Feedback Guide

How well does the solution address each of the following components?	Circle one		Suggestions on how to improve each component
Prioritized Criteria	Developing	Proficient	
Based on evidence	Developing	Proficient	
Based on scientific knowledge	Developing	Proficient	
Includes tradeoffs	Developing	Proficient	
Reduces the negative impact on environmental stability	Developing	Proficient	

Summary Task

Today we completed a class consensus discussion. How did it go?

1. One thing that went well in the discussion:

2. One thing we can improve the next time we have a discussion:

3. One person who helped me learn today:

4. What did you learn from this person?

5. One idea that I contributed to my group or my class:

Explain what you know about the following questions, based on what we discussed today.

1. Using the example of the elephant population at Gorongosa National Park, describe how using the crosscutting concept of stability and change helped you understand the tuskless elephant phenomenon.

2. Explain how human activities can can disrupt an ecosystem and threaten the survival of some species

3. Discuss some important considerations when designing solutions to human activities that are disrupting ecosystems and threatening biological diversity.

Appetite for Destruction Note Catcher

Guiding Prompts:

- What are the causes behind the decline of the Bluefin tuna?
- Who are the different stakeholders involved?
- How can we work with different stakeholders to save the Bluefin tuna from extinction?

Directions:

As you watch Appetite for Destruction: Eating Bluefin Tuna Into Extinction identify the different stakeholders (people involved) and describe their role in either the decline, or in the movement to conserve the bluefin tuna. After watching the movie, respond to the discussion prompts below.

Stakeholder	Role	Description / Notes
Sushi Chef Michael *(3:05)*	• Contributing to the decline • Wants to conserve • Both	
Sushi Chef Yoya (*6:05)*	• Contributing to the decline • Wants to conserve • Both	
Fish distributor Rex (*8:45)*	• Contributing to the decline • Wants to conserve • Both	
Wholesaler Jiro *(14:20)*	• Contributing to the decline • Wants to conserve • Both	

Discussion Questions:

After group discussion, respond to these prompts individually:

1. Develop a model that represents how humans are causing the decline of the Bluefin tuna. Be sure to include the relevant components of the system (or systems) and how those components and/or systems relate to one another at different scales.

2. Discuss why you think different stakeholders had different opinions on conserving the bluefin.

3. Why do you think that people's views on conserving the bluefin have been changing in Japan?

4. What are stakeholders might be missing from this video? Why is it important to consider everyone's view?

Overfishing Simulation

Introduction

You will engage with a simulation, Eco Ocean an Overfishing Simulation to better understand the variables involved in fishing, and different ways in which we could fish more sustainably.

Procedure:

1. Click on and read the game instructions before entering the simulation
2. Once you enter the simulation, notice the different parts of the screen. You are always the **red** fishing vessel. The other vessels are simulating other fishermen (players).
3. Play 1-2 practice rounds to get used to navigating around the screen, and notice that each round is timed.
4. The goal is to get a high sustainability score, while also scoring points through obtaining fish. The final score is the sustainability rating x the points you earn fishing.
5. Use the simulation to try out the following scenarios. Fill in your final score, sustainability rating, and observations for each.

Data Table 1. Scenarios

Round	Scenario	Evaluation	Observations
1	Choose 2 cells that are right next to each other. Stay and fish in those two cells. Take as many fish from those cells as possible, and keep fishing only in those two cells until time is up.	Fishing points ____ Sustainability rating _____ Final score _____	
2	Start in 1 cell and fish, once that cell is empty, move to a far away cell (across the board) to fish. Continue to move only to new cells after fishing only 1 time, spreading out as much as possible	Fishing points ____ Sustainability rating _____ Final score _____	
3	Choose any cell you would like, and move as much as you choose. In each cell, only fish two times, and then move on.	Fishing points ____ Sustainability rating _____ Final score _____	

Summary Questions

1. How would you define sustainable fishing in this simulation?

2. This simulation is located in the middle of the ocean, and no specific countries are shown. How does that impact how people may fish?

3. What are some new rules (other than the off limits cells) that you could add to this simulation that might promote sustainable fishing?

Extension: Use the simulation to design and test out your own solution to overfishing. Record your strategy and results below.

Simulation Reminders

You are the RED fishing vessel
To Fish:

1. Click on a cell to move your boat to that cell
2. Once your boat arrives at that cell, click the cell again. A net should appear in the cell under the boat
3. One click = one fishing event

How many fish are in a cell?

1. Hover over a cell, the number of fish appears in the cell
2. After a fishing event, hover over the cell to see how many fish are remaining
3. Each fishing event takes about half of the fish from that cell and the surrounding cells

Bones in the cell = the area is being overfished
Remember the goal is to get as many fish as possible, while still being sustainable.
he final score is calculated by the # of points earned through fishing x the sustainability score (calculated by the avg # of fish taken at each event).
Remember you are being timed!

Evaluating and Revising A Simulation

Evaluating the Overfishing Simulation

Directions: Use your experience with Eco Ocean an Overfishing Simulation to evaluate the simulation.

1. Describe how the simulation models a real life scenario. What is modeled in the simulation?

2. What variables did the simulation allow you to manipulate?

3. Describe how the simulation does not accurately reflect or model a real life scenario. What are its limitations?

Revising A Simulation

Directions: If you were able to revise the simulation to improve its ability to allow you to model overfishing and test out solutions; what would you change or build into the simulation to improve it? Describe your ideas below. In your revised simulation, keep in mind:

- How could the simulation better reflect the complexity of overfishing? (stakeholders, etc)
- What data would you like to generate, using the simulation, to test out solutions to overfishing?
- What other human activity (e.g. impact of climate change) would you like to be able to model in your simulation?
- What additional variables would you like to be able to manipulate?
- How could you revise the simulation to be able to better consider tradeoffs and constraints in testing out solutions?

Revising Elephant Decline Solution

Guiding Prompt: How does the simulation and the case of the Bluefin Tuna relate to the over exploitation of elephants? How can what you learned in this activity help you revise your proposed elephant decline solution?

Tuskless Elephant 5E - Mini Rubric

Claim #1- Hunting by humans was a cause of the extinction of the woolly mammoths

Component	Developing	Proficient
Evidence	Effectively and clearly provides evidence that includes **some** of the elements below: • At least 2 examples of evidence are provided • Provided evidence is **data** from an investigation or resource in the learning cycle • Evidence supports the claim • If appropriate, evidence that refutes the claim is included and clearly indicated	Effectively and clearly provides evidence that includes **all** of the elements below: • At least 2 examples of evidence are provided • Provided evidence is **data** from an investigation or resource in the learning cycle • Evidence supports the claim • If appropriate, evidence that refutes the claim is included and clearly indicated

Scientific Reasoning & Logic	Effectively and clearly provides scientific reasoning and logic that includes **some** of the elements below:
	• An accurate explanation of the concept of human impact on biodiversity is used to link the evidence to the claim(s) including:
	  • Human actions, such as overhunting, cause adverse impacts on habitats and biodiversity
	  • Organisms play important roles in the ecosystem that benefit humans in several ways
	  • Biodiversity decreases when species go extinct
	  • Human caused changes in the environment may lead to the decline or extinction of species
	• Includes a logic statement that links the evidence to the claim (including words such as because and therefore)
	• If appropriate, an idea or concept is used to refute or question the claim
		Effectively and clearly provides scientific reasoning and logic that includes **all** of the elements below:
		• An accurate explanation of the concept of human impact on biodiversity is used to link the evidence to the claim(s) including:
		  • Human actions, such as overhunting, cause adverse impacts on habitats and biodiversity
		  • Organisms play important roles in the ecosystem that benefit humans in several ways
		  • Biodiversity decreases when species go extinct
		  • Human caused changes in the environment may lead to the decline or extinction of species
		• Includes a logic statement that links the evidence to the claim (including words such as because and therefore)
		• If appropriate, an idea or concept is used to refute or question the claim

Model	A model that accurately represents how the claimed cause impacted the woolly mammoths with **some** of the following components: • Demonstrates interactions within and between different parts of the system, including cause and effect relationships. • Demonstrates relationships within and between systems at different scales • Demonstrates impacts on the ecosystem or other organisms with the extinction of the woolly mammoth • Used proper symbols/notations to demonstrate phenomenon components, relationships, and mechanisms.	A model that accurately represents how the claimed cause impacted the woolly mammoths with **all** of the following components: • Demonstrates interactions within and between different parts of the system, including cause and effect relationships. • Demonstrates relationships within and between systems at different scales • Demonstrates impacts on the ecosystem or other organisms with the extinction of the woolly mammoth • Used proper symbols/notations to demonstrate phenomenon components, relationships, and mechanisms.

Student Self-Evaluation Circle one			**Teacher/Peer Evaluation** Circle one		
Evidence	Developing	Proficient	**Evidence**	Developing	Proficient
Reasoning	Developing	Proficient	**Reasoning**	Developing	Proficient
Model	Developing	Proficient	**Model**	Developing	Proficient
Glow			**Glow**		
Grow			**Grow**		

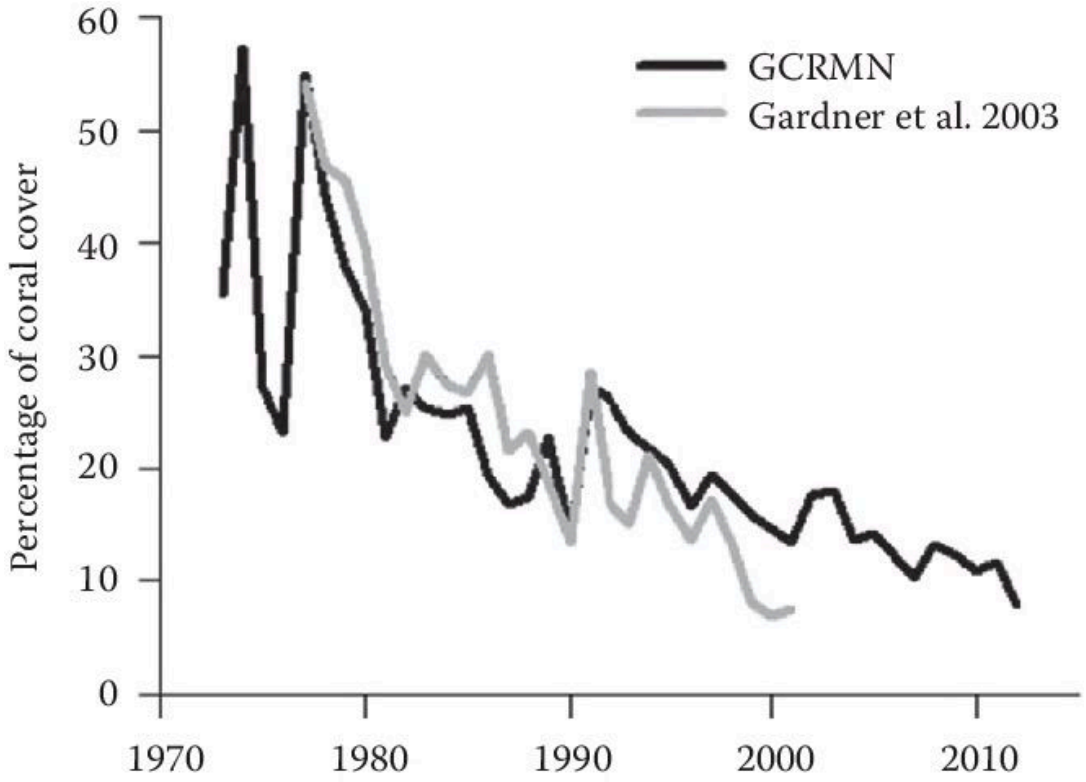
Coral Bleaching 5E

Unit 6 Woolly Mammoth	Biology
Student Name:	

Coral Reef Coverage Graph

Guiding Prompt: What trend do you see in coral reef cover (coral reef population) in the Caribbean between 1977 and 2001?

Coral look like plants, but are actually animals related to jellyfish that live *symbiotically* with a photosynthetic algae. Corals live in colonies and can secrete a calcium-based skeleton that creates the physical structure that houses many other organisms. Coral reefs are very biodiverse ecosystems, making up about 25% of marine biodiversity, even though they only occupy less than 1% of the space of the ocean.
Percent Live Coral Cover in the Caribbean from 1977 to 2002 (based on two independent population surveys)



Decline in percentage of coral cover on Caribbean coral reefs from 1963 to the present based on data compiled by the IUCN (i.e., the International Union for the Conservation of Nature's Tropical Americas Coral Reef Resilience Workshop) with yearly averages weighted by the area surveyed per study and compared to Gardner et al. (2003) (yearly averages weighted by the inverse of a study's sample variance). GCRMN, Global Coral Reef Monitoring Network. Credit: © IUCN (International Union for the Conservation of Nature).

Coral Bleaching Investigation

Research Question: What is the effect of sea surface temperature on the number of coral reef bleaching events?

Introduction: Coral bleaching is a widespread occurrence that is leading to the death and decline of coral reef habitats. In this investigation, we will explore the relationship between ocean temperature and coral bleaching. For purposes of tracking coral health in this investigation, normal temperatures are determined by averaging monthly temperatures for 1985 to 1993. The warmest normal temperature is the month with the highest average temperature, called the *maximum monthly mean* (MMM). The temperatures are measured by satellites using an infrared radiation sensor and represent sea surface temperature (SST). Only nighttime data are used to avoid overestimating heat due to solar heating of a thin layer at the sea surface.

Heat stress for the corals is assessed by a measure called *degree heating weeks* (DHW). It is a cumulative measurement of the intensity and duration of heat stress that a coral reef experiences over a period of 12 weeks, equivalent to a season. Further, the temperature data is averaged over relatively large areas of 5 km_2, but actual temperatures experienced by corals may vary greatly due to local conditions. Finally, corals can recover after the stress disappears, and the 12-week window accounts for this.

Materials:

- Location card - assigned by the instructor
- Three location graphs based on assigned location
- Copies of world maps

Procedure

1. Estimate the number of degree heating weeks (DHW) for specific years, based on the provided graphs. To calculate the number of DHWs, count the boxes under every curve above the MMM that appears during that year. For instance, 1°C above the MMM for 1 week is 1 DHW, 2°C above the MMM for 1 week is 2 DHW, and so on. Figure 3 shows several examples.

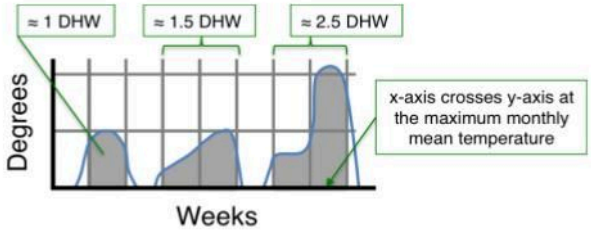


Figure 3. Schematic example for estimating DHWs. The shaded areas represent the DHWs.

Figure 3.

2. Using the example above as a guide, calculate the DHW values for your location in the years 2002, 2010, and 2014. Count all the DHWs within a 12-week window (calendar dates will vary from site to site). Tip: If the season spans January 1, then assign it to the year in which most of the heat stress occurs. For example, the 2002 hot season may actually start in December of 2001.

3. Use the following table to assign the risk level for your location for 2002, 2010, and 2014. As shown in the table, when DHW is greater than 8, coral mortality is likely and you can stop counting DHWs.

Data Table.

Location:				
Latitude:				
Longitude:				
Year	**Risk Level**			
	No Bleaching (DHW = 0)	**Bleaching Possible (0 < DHW < 4)**	**Bleaching Likely (4 ≤ DHW < 8)**	**Mortality Likely (DHW ≥ 8)**
2002				
2010				
2014				

4. Find your location on the world maps provided by your instructor. Indicate the risk level at your location for the corresponding years, using stickers or colored pencils as directed by your instructor.

Making Sense of the Coral Bleaching Investigation

Directions:
After analyzing the data and generating the world maps, use the See-Think-Wonder graphic organizer below to make sense of the data. Use the prompts in the See and Think columns to get you started.

See Things that I see or notice in the data	**Think** What the data makes me think about, or connections that I can make	**Wonder** Questions that I have about the data
• What do you notice about the DHW values over time in your location? • What do you notice about the DHW values over time in all of the locations? • What do you notice about the relationship between the DHW value and coral bleaching?	• Why are some coral reefs experiencing bleaching events and not others? • What additional data would you collect or analyze to establish a cause and effect relationship between rising sea surface temperatures and coral decline? • How did calculating and creating graphs and maps of the DHW values help you better understand the phenomenon of coral bleaching?	

Coral Bleaching Investigation Rubric

Student Rubric - Coral Bleaching Investigation
How did you do in the investigation?

	Student Self-Score Circle one		
I know how this investigation connects to our current unit.	No - I need help.	Almost	Yes
I was able to contribute to the See-Think-Wonder and respond to the evaluation questions.	No- I need help.	Almost	Yes
I used my time well in this investigation.	No	Mostly	Yes
I plan to come in for extra help to complete parts of the investigation or ask questions.	No		Yes

What other resources could you have used to get more out of this investigation?

- More time
- More resources
- More information
- More help from my partners
- More help from my teacher
- Other:

Partner Rubric - Coral Bleaching Investigation
How did your partners do in the investigation?

Directions: Think back to how your partners participated in the lab. For each of the four categories, write your partner's or partners' names in the appropriate box.

	Unsatisfactory	**Pretty Good**	**Excellent**
Contributions	Did not participate.	Did the minimum of what was required.	Provided useful ideas when participating in discussion
Working with Others	Rarely listened to others. Disrupted or discouraged others' attempts to participate.	Usually listened to, shared with, and supported the efforts of others.	Listened to, shared with, and supported the efforts of others.

Time Management	Procrastinated, did not use school time or schedule provided to get work completed.	Mostly used time well and completed investigation on time.	Used time well to ensure things get done on time.

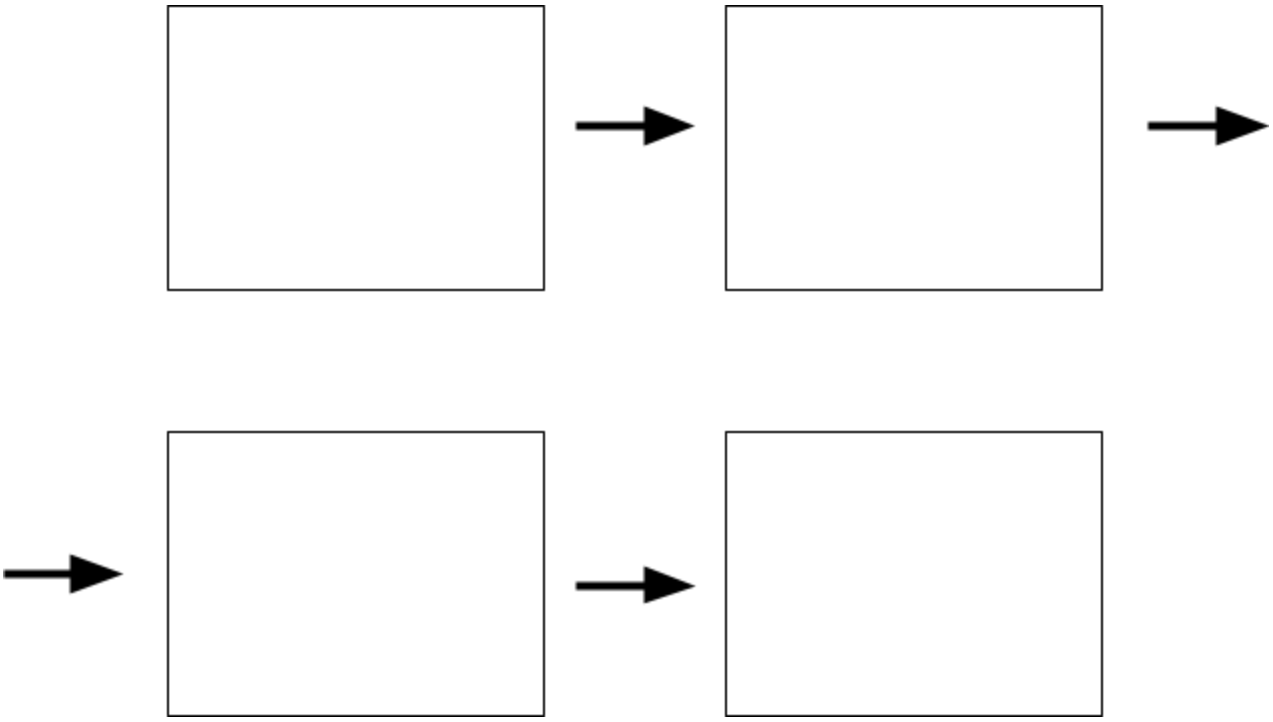
Cause & Effect Organizer Coral Bleaching

Guiding prompt: How can we explain the phenomenon of coral bleaching?

Directions:

1. Watch the first 2 minutes of the video, HHMI BioInteractive: Coral Bleaching Animation to review the structure and function of a coral colony. Use the space below to describe the structure of a coral reef.

2. Based on the data from the coral bleaching investigation, fill in the first 1-2 boxes of the cause and effect graphic organizer below.
3. Watch the remainder of the video, HHMI BioInteractive: Coral Bleaching Animation listening for more information that responds to the guiding prompt. Fill in the remainder of the cause and effect organizer based on the video simulation of the coral bleaching phenomenon.



Carbon Cycle Investigation Part 1

Introduction: In this investigation we will use a simulation to explore the movement of carbon through different parts of the earth. Simulations are models, and this simulation lets us explore the *projected* movement of carbon into the future.

Research Question:

Procedure:

1. Open up the simulation, Annenberg Learner Interactive Carbon Cycle Lab and take a moment to become familiar with the different parts.
2. In the data table below, record the total amount of carbon in each part of the earth, starting with 2010. These are called *carbon sinks*. Note that each gray block represents 25 GT (gigatons) of carbon. The number next to each sink is the number of gigatons of carbon stored in that sink. The + next to a number represents the change in amount of carbon. To find the total amount of carbon, add the amount of change with the initial number.
    a. Example: in 2010 to find the total amount of carbon in the soil

1800 + 200 = 2000 GT of carbon

3. Run the simulation to 2110 with the default settings, and, using your Data Table 1, record the total carbon levels in each "sink" (terrestrial plants, soil, oil and gas, coal, surface ocean, and deep ocean) at years: 2060, 2110, 2160, and 2300

Data Table 1:

Carbon Sink	Year 2010	Year 2060	Year 2110	Year 2160	Year 2300
Atmosphere					
Biosphere					
Terrestrial Plants					
Soil					
Fossil Fuels					
Coal					
Oil & Gas					
Ocean					
Ocean Surface					
Deep Ocean					

Data Analysis:

1. Describe the trend for each carbon sink from 2010 to 2300.

---

2. Using the data generated by the simulation, determine the mathematical relationship between the percentage increase in fossil fuel consumption and the increase in atmospheric carbon between the years of 2010 and 2110. Is the relationship linear? Why or why not?

Carbon Cycle Investigation Part 2

Introduction: In this part of the investigation you will use the simulation, Annenberg Learner Interactive Carbon Cycle Lab to further explore an additional variable.

Research Question:

Procedure:

1. Using this animation, what additional variables could you investigate to help us better understand the carbon cycle and how the release of carbon dioxide is impacting the earth? Brainstorm your ideas:

---

2. Confer with your group, which variable(s) would you like to investigate? Develop a claim based on the variable you will investigate.

Possible sentence starters:

- If _____ increases/ decreases then _____ will increase/ decrease
- Changing _____ variable will impact atmospheric carbon dioxide because _____
- The data indicates that _____ because _____
- Changing _____ will impact _____

---

3. Create an appropriate data table below.
4. Use the simulation to investigate the new variable, using the data table to record your observations.
5. Determine how to best analyze and mathematically represent the data to support your claim.

Making Sense of the Carbon Cycle Investigation

Directions: Use the data you collected and analyzed during the investigation to respond to the following questions.

Summary Questions

1. Why would carbon in plants increase as the amount of carbon dioxide in the atmosphere increased?

2. How would you describe the movement of carbon throughout Earth as a system?

3. When the fossil fuels emissions decreased due to depletion, which sinks responded quickly and which sinks responded to the change more slowly?

4. Which additional variable(s) that you investigated had a significant impact on the amount of carbon dioxide in the atmosphere? Why?

5. What additional information do you need to better understand why coral bleaching events occur?

Carbon Cycle Investigation Rubric

Student Rubric - Carbon Cycle Investigation
How did you do in the investigation?

	Student Self-Score Circle one		
I know how this investigation connects to our current unit.	No - I need help.	Almost	Yes
I was able to contribute to the See-Think-Wonder and respond to the evaluation questions.	No- I need help.	Almost	Yes
I used my time well in this investigation.	No	Mostly	Yes
I plan to come in for extra help to complete parts of the investigation or ask questions.	No		Yes

What other resources could you have used to get more out of this investigation?

- More time
- More resources
- More information
- More help from my partners
- More help from my teacher
- Other:

Partner Rubric - Carbon Cycle Investigation
How did your partners do in the investigation?

Directions: Think back to how your partners participated in the lab. For each of the four categories, write your partner's or partners' names in the appropriate box.

	Unsatisfactory	**Pretty Good**	**Excellent**
Contributions	Did not participate.	Did the minimum of what was required.	Provided useful ideas when participating in discussion
Working with Others	Rarely listened to others. Disrupted or discouraged others' attempts to participate.	Usually listened to, shared with, and supported the efforts of others.	Listened to, shared with, and supported the efforts of others.

Time Management	Procrastinated, did not use school time or schedule provided to get work completed.	Mostly used time well and completed investigation on time.	Used time well to ensure things get done on time.

Carbon Cycle Model

Directions: Use your experience with the Carbon Cycle Investigation to generate an initial model that represents how carbon moves and interacts through different parts of the earth. In your model, be sure to include the relevant components and processes (photosynthesis, cellular respiration, geosphere, atmosphere, biosphere, and hydrosphere) and demonstrate how these different components and processes interact with each other as a system.

Carbon Cycle Model Peer Rubric

	Developing	Proficient
Components of the Model	**Some** of the relevant components of the model are identified and described including: • The inputs and outputs of photosynthesis • The inputs and outputs of cellular respiration • The biosphere • The atmosphere • The geosphere • The hydrosphere	**All** of the relevant components of the model are identified and described including: • The inputs and outputs of photosynthesis • The inputs and outputs of cellular respiration • The biosphere • The atmosphere • The geosphere • The hydrosphere
Relationships	**Some** of the relationships between components in the model are clearly described including: • The exchange of carbon between organisms • The exchange of carbon between organisms and the environment • The role of storing carbon in organisms as part of the carbon cycle • Describes the contribution of photosynthesis and cellular respiration to the exchange of carbon within and among the biosphere, atmosphere, hydrosphere, and geosphere	**All** of the relationships between components in the model are clearly described including: • The exchange of carbon between organisms • The exchange of carbon between organisms and the environment • The role of storing carbon in organisms as part of the carbon cycle • Describes the contribution of photosynthesis and cellular respiration to the exchange of carbon within and among the biosphere, atmosphere, hydrosphere, and geosphere
How can we improve the model?		

Carbon Cycle Text

A **carbon** atom can be a part of a plant one day, an animal the next day, and then travel downstream as a part of a river's water the following day. These carbon atoms can be a part of both biotic things like plants, as well as abiotic things like water, air, and even rocks. The same atoms are recycled over and over in different parts of the Earth. This type of cycle of atoms between living and nonliving things is known as a **biogeochemical cycle**. In other words, the atoms that make up all matter, cycle through different components of an ecosystem.

All of the atoms that are building blocks of living things are a part of biogeochemical cycles. The most common of these are the carbon and nitrogen cycles.

Atoms of carbon and nitrogen are able to move around the planet through these cycles. For example, an atom of carbon diffuses from the air into the ocean water where it is used by floating plankton during photosynthesis to get the nutrition they need. There is the possibility that this little carbon atom becomes part of the plankton's outer shell, or a part of the skeleton of the larger animal that eats it, and then part of a sedimentary rock when the living things die and only bones are left behind. Carbon that is a part of rocks and fossil fuels like oil, coal, and natural gas may be held away from the rest of the carbon cycle for a long time. When carbon is found in the ocean it is a part of the **hydrosphere**. When it makes up rocks, minerals, and fossil fuels it is in the **geosphere**. All of the carbon found in living things such as plants and animals, is residing in the **biosphere,** and carbon as a gas (carbon dioxide) is generally a part of the **atmosphere**.

- Carbon moves from the atmosphere to plants. In the atmosphere, carbon is attached to oxygen in a gas called carbon dioxide (CO_2). Through the process of **photosynthesis**, carbon dioxide is pulled from the air to produce glucose made from carbon for plant growth.
- Carbon can move out of animals and plants through the process of **cellular respiration**. When organisms generate energy, they use oxygen and glucose. Carbon dioxide is one waste product of that process which is released into the environment
- Carbon moves from plants to animals. Through food chains, the carbon that is in plants moves to the animals that eat them. Animals that eat other animals get carbon from their food too.
- Carbon moves from plants and animals to soils. When plants and animals die, their bodies, wood and leaves decays bringing the carbon into the ground. Some are buried and will become fossil fuels in millions and millions of years, thus becoming a part of the geosphere.
- Carbon moves from the atmosphere to the oceans and vice versa through the process of diffusion.. The oceans, and other bodies of water, absorb some carbon from the atmosphere. The carbon is dissolved into the water (the hydrosphere) and may become a part of the biosphere when incorporated into the bodies of sea animals.

Summary Task

Today we completed a class consensus discussion. How did it go?

1. One thing that went well in the discussion:

2. One thing we can improve the next time we have a discussion:

3. One person who helped me learn today:

4. What did you learn from this person?

5. One idea that I contributed to my group or my class:

Explain what you know about the following questions, based on what we discussed today.

1. Using the trends found in the data you worked with throughout this learning cycle, explain how human activities, such as the combustion of fossil fuels, can disrupt an ecosystem and serve to limit population growth of organisms.

2. Discuss the use of scale and orders of magnitude in your final group model. How did representing the phenomenon at different scales help you understand why we saw an increase in coral bleaching events?

3. In this 5E learning cycle, you interacted with and created different models of how carbon cycles through different parts of the earth. Describe how the models you engaged with are different from the actual cycling of carbon via photosynthesis and cellular respiration.

Read Generate Sort Solve Organizer

This organizer can be created on chart paper, or printed as a poster.

Read the prompt and the text or data sources silently.

"What evidence do we have that organisms are able to adapt and survive climate change? Evaluate the claim that organisms may be able to adapt to impending climate change. What is the evidence and reasoning behind that claim?"

Generate ideas:

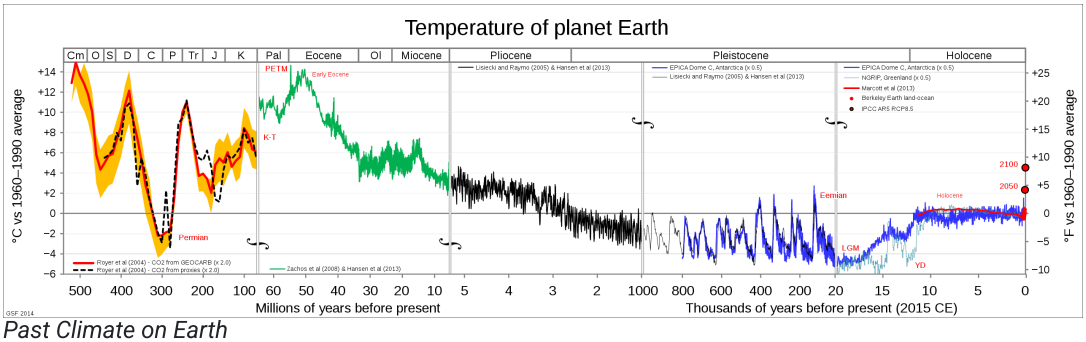
Name: _____	**Name: _____**	**Name: _____**

Sort - Discuss each solution or idea and **star** the ideas that seem the most useful

Solve - Individually write your **response** to the prompt incorporating the most useful ideas from the sorting process! Be sure to include the cross cutting concept of stability and change in your final response.

Climate Change & Mammoths Text

Did climate change contribute to the extinction of the woolly mammoths?



Past Climate on Earth

A couple of recent studies have provided evidence for the possible negative impact of climate change on the woolly mammoths. Both studies used similar methods to better understand past climate change and its impact on organisms such as the woolly mammoth. They collected ancient DNA samples from museum specimens and from ancient plant and animal remains including urine, feces, and skin cells taken from soil samples from sites in the Arctic where mammoth remains have been found. They dated these samples using radiocarbon dating and matched up paleoclimate data with the age of the samples so they knew what the climate was when those organisms were alive.

One study found that short, rapid warming events, recorded during the last ice age or Pleistocene from 60,000 to 12,000 years ago, coincided with major extinction events (such as the extinction of the mammoth). They found these warming events continued over thousands of years, with temperatures rising up 7 to 28 degrees Fahrenheit. "This abrupt warming had a profound impact on climate that caused marked shifts in global rainfall and vegetation patterns," Alan Cooper, the lead author of the study explained.

At first, the researchers suspected the extinctions were linked to intense cold snaps. But as more fossil-DNA became available from museum specimen collections and through improvements in carbon dating and temperature records that showed better resolution through time, the story began to change.

"We first noticed a pattern in our ancient DNA studies about 10 years ago, but originally thought that it must relate to short intense cold snaps." Cooper said. "We developed our new combined climate record to get increased resolution about the timing of climatic events and, as more ancient DNA datasets became available, it became obvious that the association was with the rapid warming events, not the cold snaps. A giveaway is the lack of extinctions during the peak cold event -- the Last Glacial Maximum."

“We have finally been able to prove that it was not just the climate changing that was the problem, but the speed of it that was the final nail in the coffin – they (the mammoths) were not able to adapt quickly enough when the landscape dramatically transformed and their food became scarce. As the climate warmed up, trees and wetland plants took over and replaced the mammoth’s grassland habitats” Cooper explained.

A second study, published in the journal Nature, also examined ancient DNA found in ancient plant and animal remains including urine, feces, and skin cells taken from soil samples from sites in the Arctic where mamoths were mammoth remains have been found.

Dr Yucheng Wang, first author of the paper, said: “The most recent Ice Age – called the Pleistocene – ended 12,000 years ago when the glaciers began to melt and the roaming range of the herds of mammoths decreased. It was thought that mammoths began to go extinct then but we also found they actually survived

beyond the Ice Age all in different regions of the Arctic and into the Holocene – the time that we are currently living in – far longer than scientists realized.

“We zoomed into the intricate detail of the environmental DNA and mapped out the population spread of these mammals and showed how it becomes smaller and smaller and their genetic diversity gets smaller and smaller too, which made it even harder for them to survive.

“When the climate got wetter and the ice began to melt it led to the formation of lakes, rivers, and marshes. The ecosystem changed and the biomass of the vegetation reduced and would not have been able to sustain the herds of mammoths. We have shown that climate change, specifically precipitation, directly drives the change in the vegetation”

Another researcher on the project, Prof Willerslev said: “This is a stark lesson from history and shows how unpredictable climate change is – once something is lost, there is no going back. Precipitation was the cause of the extinction of woolly mammoths through the changes to plants. The change happened so quickly that they could not adapt and evolve to survive.”

It's important to remember that the climate change that occurred during the time of the mammoths was not caused by humans, rather was a natural phenomenon. Although there are natural cycles of climate change on earth, human-caused climate change is happening at a much faster rate than in the past.

Coral Bleaching 5E - Mini Rubric

Claim #2- Climate change was a cause of the extinction of the woolly mammoths

Component	Developing	Proficient
Evidence	Effectively and clearly provides evidence that includes **some** of the elements below: • At least 2 examples of evidence are provided • Provided evidence is **data** from an investigation or resource in the learning cycle • Evidence supports the claim • If appropriate, evidence that refutes the claim is included and clearly indicated	Effectively and clearly provides evidence that includes **all** of the elements below: • At least 2 examples of evidence are provided • Provided evidence is **data** from an investigation or resource in the learning cycle • Evidence supports the claim • If appropriate, evidence that refutes the claim is included and clearly indicated

Scientific Reasoning & Logic	Effectively and clearly provides scientific reasoning and logic that includes **some** of the elements below:
	• An accurate explanation of the concept of human impact (climate change) is used to link the evidence to the claim(s) including:
	  • Human actions, such as the combustion of fossil fuels, is disrupting the normal functioning of the carbon cycle, leading to climate change
	  • Excessive carbon dioxide in the atmosphere (along with other greenhouse gasses) cases the temperature of the earth to increase
	  • Human actions, such as climate change, cause adverse impacts on habitats and biodiversity and may lead to the decline or extinction of species
	• Includes a logic statement that links the evidence to the claim (including words such as because and therefore)
	• If appropriate, an idea or concept is used to refute or question the claim
		Effectively and clearly provides scientific reasoning and logic that includes **all** of the elements below:
		• An accurate explanation of the concept of human impact (climate change) is used to link the evidence to the claim(s) including:
		  • Human actions, such as the combustion of fossil fuels, is disrupting the normal functioning of the carbon cycle, leading to climate change
		  • Excessive carbon dioxide in the atmosphere (along with other greenhouse gasses) cases the temperature of the earth to increase
		  • Human actions, such as climate change, cause adverse impacts on habitats and biodiversity and may lead to the decline or extinction of species
		• Includes a logic statement that links the evidence to the claim (including words such as because and therefore)
		• If appropriate, an idea or concept is used to refute or question the claim

Model	A model that accurately represents how the claimed cause impacted the woolly mammoths with **some** of the following components: • Demonstrates interactions within and between different parts of the system, including cause and effect relationships. • Demonstrates relationships within and between systems at different scales • Demonstrates impacts on the ecosystem or other organisms with the extinction of the woolly mammoth • Used proper symbols/notations to demonstrate phenomenon components, relationships, and mechanisms.	A model that accurately represents how the claimed cause impacted the woolly mammoths with **all** of the following components: • Demonstrates interactions within and between different parts of the system, including cause and effect relationships. • Demonstrates relationships within and between systems at different scales • Demonstrates impacts on the ecosystem or other organisms with the extinction of the woolly mammoth • Used proper symbols/notations to demonstrate phenomenon components, relationships, and mechanisms.

Student Self-Evaluation Circle one			**Teacher/Peer Evaluation** Circle one		
Evidence	Developing	Proficient	**Evidence**	Developing	Proficient
Reasoning	Developing	Proficient	**Reasoning**	Developing	Proficient
Model	Developing	Proficient	**Model**	Developing	Proficient
Glow			**Glow**		
Grow			**Grow**		

Kelp Forest 5E

Unit 6 Woolly Mammoth	Biology
Student Name:	

Map See-Think-Wonder Graphic Organizer

See	Think	Wonder

Kelp Forest & Urchin Barren Ecosystem Introduction

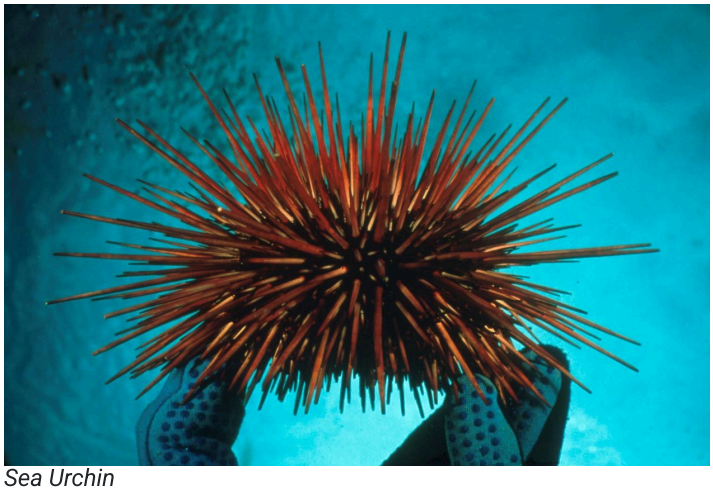
Kelp Forests

Kelp forests are ecosystems dominated by large algae that grow tall (up to 175 feet above the ocean floor!) and resemble an underwater tree. They grow in dense groupings much like a forest on land. Kelp forests tend to grow in cold, nutrient-rich water. Kelp can grow very fast, up to 18 inches in a day in ideal conditions, and provide shelter and food for a wide variety of organisms. As kelp require sunlight for photosynthesis, they must grow in shallow coastal areas that allow for sufficient sunlight.

Kelp

Urchin Barrens

Urchin barrens are ecosystems that are dominated by sea urchins. Urchins are invertebrates (they don't have a backbone) and are usually covered in spines. Sea urchins are slow-moving organisms that eat algae, like kelp. Urchin barrens are found in cold nutrient-rich water along the coasts. Other organisms live in urchin barrens beyond sea urchins, such as sea stars.



Sea Urchin

Kelp & Barrens Investigation

Research Question:

Introduction:

Across the globe, scientists have been documenting the presence of kelp forests and urchin barrens for a very long time. They have even used archaeological evidence to infer which ecosystem was present during a given time period. Therefore, for any given location, scientists have a lot of information about which ecosystem type was present, for how long, and if it changed to a different ecosystem (kelp to urchin or urchin to kelp) and even why it might have changed.

One important factor that ecologists (scientists that study ecosystems) investigate is the *stability* of an ecosystem (being able to stay relatively the same). Ecologists continue to study both kelp forests and urchin barrens ecosystems to better understand the stability of both, and what types of events cause ecosystem shifts (change from one ecosystem to another).

Procedure:

1. Based on data observed in the Engage phase, identify 1-3 claims about the stability of these two ecosystems. Record them below in the space provided.
2. Analyze the data from the data table below to identify additional evidence on the claim(s) you identified.
3. Note down your ideas and questions in the See-Think-Wonder graphic organizer.

Claims:

Table 1. Survey of sea urchin barrens documented throughout the range of kelp forest ecosystems

Legend:
K - Kelp Forest
B - Urchin Barrens
→ - a change from one ecosystem to another

Location on Map	Ecosystem shift (change from one ecosystem to another)	Years documented in barrens state	Years documented in kelp forest state	Recorded disturbances at each ecosystem shift
#1	K→B→K→B	100	112	Changes in otter population

#2	B→K	No data	No data	Increase in otter population
#3	B→K	No data	No data	Increase in otter population
#7	K→B→K	2	17	Severe storms
#8	K→B	4	2	Overgrazing of kelp by urchins
#9	B→K	5	21	Urchin disease
#11	K→B	6	10	La Nina event
#12	B	7	No data	La Nina event
#13	B	No data	No data	La Nina event
#14	K→B→K	20	32	Overfishing, urchin harvest
#15	K→B→K	4	3	Urchin population increase, urchin disease
#23	K→B→K	18	10	Urchin population increase, urchin population decrease
#23	K→B	40	32	Urchin population increase
#24	B→K	17	25	Manual urchin removal
#29	K→B	3	1	Overfishing
#31	B→K	2	12	Manual urchin removal
#32	B	2	7	No data
#33	B	No data	No data	No data
#34	K→B→K	22	18	Ocean current change, lobster increase
#35	K→B	15	11	Ocean current change
#36	K→B	2	13	Increase in otter population
#37	K→B	18	20	Increase in otter population

What are some of the different ways you could analyze the data found in Table 1?

Include at least one graph of the data in order to mathematically represent the trends seen in this data set. Complete your analysis below.

Making Sense of the Kelp & Barrens Investigation

In this investigation you generated claim(s) about the stability of two different ecosystems that can be found in the same geographical location. Based on the map, and the data set you analyzed, complete the See-Think-Wonder Table and respond to the prompts that follow.

See	Think	Wonder

1. What trends did you notice in the data?

2. Based on the analysis, what claim do you believe has the most compelling evidence? Why?

3. Based on the data, why do you think an ecosystem (kelp or urchin barrens) would change to a different ecosystem, and why would it stay stable (not change)?

4. What questions do you still have about what makes an ecosystem stable, or why kelp forests and urchin barrens look really different but can exist in the same geographic location?

Kelp & Barrens Investigation Rubric

Student Rubric - Kelp & Barrens Investigation
How did you do in the investigation?

	Student Self-Score Circle one		
I know how this investigation connects to our current unit.	No - I need help.	Almost	Yes
I was able to contribute to the See-Think-Wonder and respond to the evaluation questions.	No- I need help.	Almost	Yes
I used my time well in this investigation.	No	Mostly	Yes
I plan to come in for extra help to complete parts of the investigation or ask questions.	No		Yes

What other resources could you have used to get more out of this investigation?

- More time
- More resources
- More information
- More help from my partners
- More help from my teacher
- Other:

Partner Rubric - Kelp & Barrens Investigation
How did your partners do in the investigation?

Directions: Think back to how your partners participated in the lab. For each of the four categories, write your partner's or partners' names in the appropriate box.

	Unsatisfactory	**Pretty Good**	**Excellent**
Contributions	Did not participate.	Did the minimum of what was required.	Provided useful ideas when participating in discussion
Working with Others	Rarely listened to others. Disrupted or discouraged others' attempts to participate.	Usually listened to, shared with, and supported the efforts of others.	Listened to, shared with, and supported the efforts of others.

Time Management	Procrastinated, did not use school time or schedule provided to get work completed.	Mostly used time well and completed investigation on time.	Used time well to ensure things get done on time.

Summary Task

Today we completed a class consensus discussion. How did it go?

1. One thing that went well in the discussion:

2. One thing we can improve the next time we have a discussion:

3. One person who helped me learn today:

4. What did you learn from this person?

5. One idea that I contributed to my group or my class:

Explain what you know about the following questions, based on what we discussed today.

1. Based on the evidence you collected, including the ecosystem models, explain ecosystem stability.

2. Based on the evidence and scientific reasoning discussed in this learning cycle, discuss your understanding of how both kelp forests and urchin barren ecosystems can be found in the same geographic locations, but at different periods of time.

Think-Talk-Open Exchange Notetaker

Guiding Prompt:
We have discussed that under certain circumstances, kelp forests can shift to urchin barrens, and urchin barrens can shift to kelp forests. One could argue that both are stable, resilient ecosystems – or that one or the other is more resilient. Choose one argument to evaluate. Support your analysis by discussing the available evidence and reasoning. What additional evidence would be relevant to your argument?

Initial Response:

Revised Response:

Ecosystem Resiliency Text

A Tale of Two Kelp Forests

Within an ecosystem, populations of organisms are limited or regulated through different **feedback mechanisms**. These interactions between and among organisms, and between organisms and their environment, serve to keep the numbers and types of organisms relatively constant over long periods of time. Examples of interactions include: predator-prey interactions, competition, and the amount of nutrients or water that comes into and out of an ecosystem.

Sometimes a lack of nutrients limits plant growth, therefore the ecosystem can only support a limited number of herbivores and the carnivores that prey on them. In other circumstances, plantlife is able to flourish and support a wide range of herbivores, only because predators regulate their populations. Predators keep the population of herbivores low, so that they do not devastate the available producers.

Ecosystems are dynamic systems that are constantly under the influence of outside forces. Natural disturbances, such as storms, may negatively impact how an ecosystem functions. Human influences, such as pollution and exploitation, can also cause changes and place stress on a habitat. **Ecosystem resilience** refers to how easily an ecosystem can resist significant change, or bounce back, after a modest disturbance or new pressure is applied to the system.

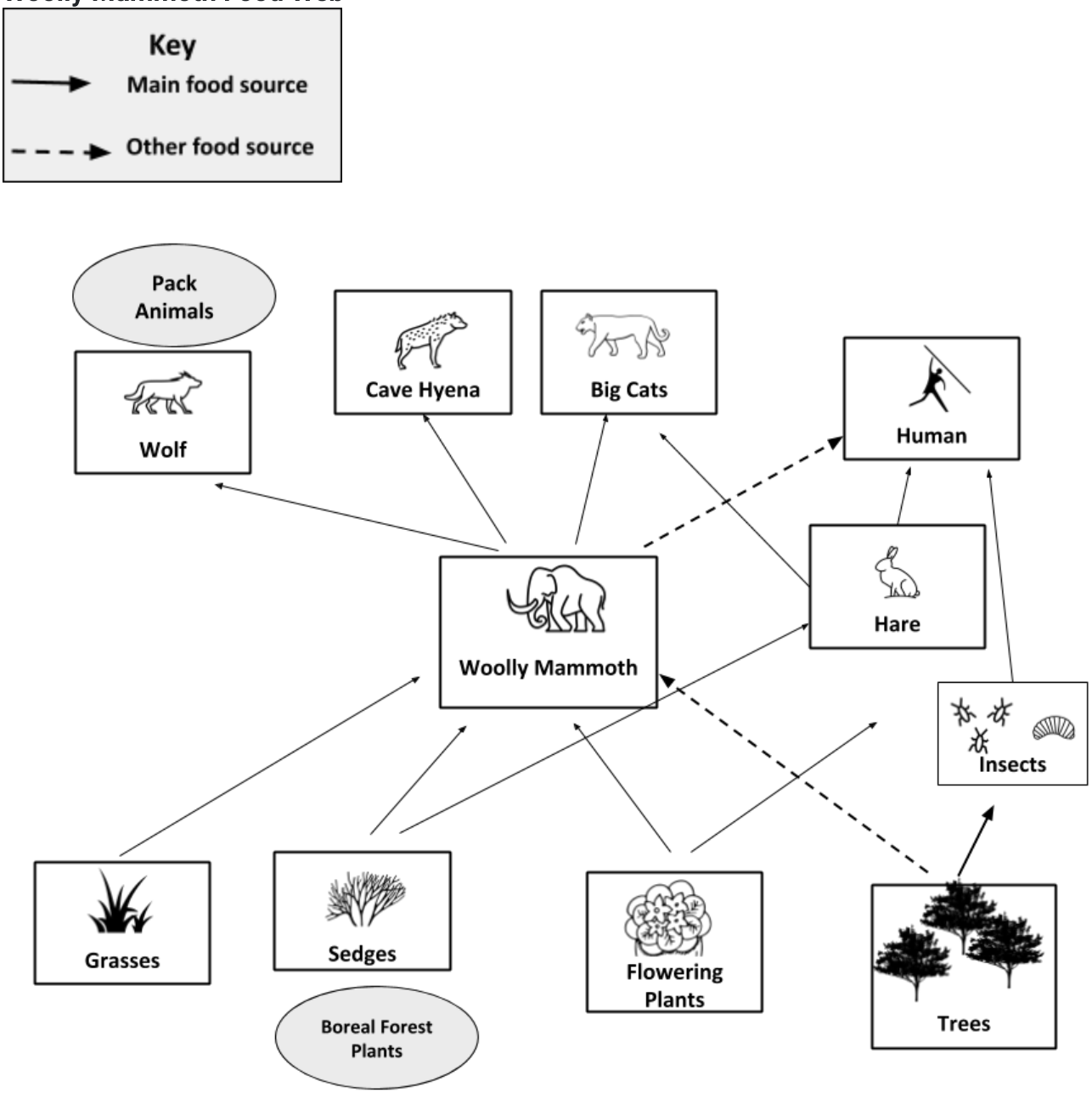
For example, in Alaskan kelp forests, sea otters control populations of herbivorous sea urchins through predation. When sea otters are removed from the ecosystem (for example, by human exploitation), urchin populations are released from predatory control and grow dramatically. This leads to increased herbivore pressure on local kelp stands. Over consumption of the kelp itself results in the loss of physical ecosystem structure and subsequently, the loss of many other species that live in and use this habitat. In Alaskan kelp forest ecosystems, sea otters are the **keystone species** that serves to regulate a stable ecosystem. The otter is considered a keystone, because it exerts an inordinate amount of influence (compared to other species) in maintaining the ecosystem.

In Southern California, kelp forests persist without sea otters and the control of herbivorous urchins is instead maintained by a variety of predators including lobsters and large fishes. The effect of removing one predator in this ecosystem differs from Alaska because **redundancy** exists in the trophic levels (top predators) and other predatory species can continue to regulate urchins. In other words, because the California kelp forests have a more **complex food web**, with multiple top predators, it is less likely to succumb to urchin overpopulation than the Alaskan kelp forest that has only the otter.

When urchin populations are allowed to grow uncontrolled, they can completely destroy all of the kelp. This process leads to a new stable ecosystem, called urchin barrens, in which urchins dominate the area. Although this type of ecosystem is stable, it is much less **biodiversity** than the original kelp forest, because only a few species can exist there. Recovery can only occur if urchin populations are controlled, allowing the kelp to grow back. Generally, biodiverse ecosystems include more complex food webs that can withstand disturbances. Biodiversity includes not only many different types of species that overlap in their roles, but the genetic diversity of a population.

Woolly Mammoth Ecosystem

Woolly Mammoth Food Web



Kelp Forest 5E - Mini Rubric

Claim #3- Ecosystem disruption/ instability was a cause of the extinction of the woolly mammoths

Component	Developing	Proficient
Evidence	Effectively and clearly provides evidence that includes **some** of the elements below: • At least 2 examples of evidence are provided • Provided evidence is **data** from an investigation or resource in the learning cycle • Evidence supports the claim • If appropriate, evidence that refutes the claim is included and clearly indicated	Effectively and clearly provides evidence that includes **all** of the elements below: • At least 2 examples of evidence are provided • Provided evidence is **data** from an investigation or resource in the learning cycle • Evidence supports the claim • If appropriate, evidence that refutes the claim is included and clearly indicated

Scientific Reasoning & Logic	Effectively and clearly provides scientific reasoning and logic that includes **some** of the elements below:
	• An accurate explanation of the concept of ecosystem stability is used to link the evidence to the claim(s) including:
	  ◦ Complex interactions maintain relatively stable populations over time
	  ◦ Moderate biological or physical (environmental) disturbances usually do not change ecosystem functioning
	  ◦ Extreme fluctuations or disturbances can impair the stability of an ecosystem
	  ◦ Resiliency of an ecosystem describes how quickly it can bounce back from a disturbance
	• Includes a logic statement that links the evidence to the claim (including words such as because and therefore)
	• If appropriate, an idea or concept is used to refute or question the claim
		Effectively and clearly provides scientific reasoning and logic that includes **all** of the elements below:
		• An accurate explanation of the concept of ecosystem stability is used to link the evidence to the claim(s) including:
		  ◦ Complex interactions maintain relatively stable populations over time
		  ◦ Moderate biological or physical (environmental) disturbances usually do not change ecosystem functioning
		  ◦ Extreme fluctuations or disturbances can impair the stability of an ecosystem
		  ◦ Resiliency of an ecosystem describes how quickly it can bounce back from a disturbance
		• Includes a logic statement that links the evidence to the claim (including words such as because and therefore)
		• If appropriate, an idea or concept is used to refute or question the claim

Model	A model that accurately represents how the claimed cause impacted the woolly mammoths with **some** of the following components: • Demonstrates interactions within and between different parts of the system, including cause and effect relationships. • Demonstrates relationships within and between systems at different scales • Demonstrates impacts on the ecosystem or other organisms with the extinction of the woolly mammoth • Used proper symbols/notations to demonstrate phenomenon components, relationships, and mechanisms.	A model that accurately represents how the claimed cause impacted the woolly mammoths with **all** of the following components: • Demonstrates interactions within and between different parts of the system, including cause and effect relationships. • Demonstrates relationships within and between systems at different scales • Demonstrates impacts on the ecosystem or other organisms with the extinction of the woolly mammoth • Used proper symbols/notations to demonstrate phenomenon components, relationships, and mechanisms.

Student Self-Evaluation Circle one			**Teacher/Peer Evaluation** Circle one		
Evidence	Developing	Proficient	**Evidence**	Developing	Proficient
Reasoning	Developing	Proficient	**Reasoning**	Developing	Proficient
Model	Developing	Proficient	**Model**	Developing	Proficient
Glow			**Glow**		
Grow			**Grow**		

Passenger Pigeon 5E

Unit 6 Woolly Mammoth	Biology
Student Name:	

Introduction to the Passenger Pigeon

What questions do we have about the passenger pigeon?

In the Spring of 1850, a young Potawatomi tribal leader named Simon Pokagon was camping at the headwaters of Michigan's Manistee River. He was startled by an approaching loud sound. He described the sound like, "an army of horses laden with sleigh bells was advancing through the deep forests towards me," He went on to explain, "As I listened more intently, I concluded that instead of the tramping of horses it was distant thunder; and yet the morning was clear, calm, and beautiful." The mysterious sound came "nearer and nearer," until Pokagon deduced its source: "While I gazed in wonder and astonishment, I beheld moving toward me in an unbroken front of millions of pigeons, the first I had seen that season."

These were passenger pigeons, one of the most abundant birds that has ever lived. Throughout the 19th century, witnesses had described similar sightings of pigeon migrations. They described how the flocks of pigeons took hours to pass over a single spot, darkening the sky and rendering normal conversation impossible.

Nesting birds took over whole forests, forming what John James Audubon in 1831 called "solid masses as large as hogs-heads." Observers reported trees crammed with dozens of nests apiece, collectively weighing so much that branches would snap off and trunks would fall over.

Because they existed in such large groups, hunting them was easy. People shot them down, dozens at a time, and could even hit and kill them with rocks, clubs, and rakes . They shot the pigeons and trapped them with nets, torched their roosts, and asphyxiated them with burning sulfur. They poisoned them with whiskey-soaked corn. Hunters began killing the birds in their large communal nesting spots, harvesting the adults and even the baby birds. The invention and expansion of the railroad system allowed for easy transport of the pigeons to cities, fueling a commercial hunting industry.

By the mid-1890s, wild flock sizes numbered in the dozens rather than the hundreds of millions (or even billions). Then they disappeared altogether, except for three captive breeding flocks spread across the Midwest. About September 1, 1914, the last known passenger pigeon, a female named Martha, died at the Cincinnati Zoo. She was roughly 29 years old, with a palsy that made her tremble. Not once in her life had she laid a fertile egg.

Some scientists believe that the passenger pigeon was uniquely adapted to living in very large, communal flocks. Traveling in huge flocks, the pigeons were able to ward off predators by their sheer size in numbers. They also devoured nuts and other food, easily out-competing other birds and animals. As the population dwindled due to hunting and human exploitation, the remaining individuals could no longer function in the same way in which they had evolved over millions of years, and they did not have enough time to adapt to their new flock size. Therefore, they were functionally extinct before the few remaining individuals actually passed away.

The extinction of the passenger pigeon coincided with dramatic changes in forest ecosystems, such as a reduction in biodiversity of trees and other species. Some of that change was due to large amounts of deforestation happening at the same time period, as people spread across the country and used land for building and agriculture. But some scientists believe that the loss of the passenger pigeon itself contributed to the decline in biodiversity as well.

We are currently in a massive moment of extinction. It is estimated that 75-150 species go extinct every day, from a combination of hunting but also ecosystem collapse. Nearly 20 million acres of forest are destroyed every year, and more land and ocean is destroyed by human use. In order to keep ecosystems as healthy as possible, or to return them to health, the most critical species have to be supported, maintained, or reintroduced.

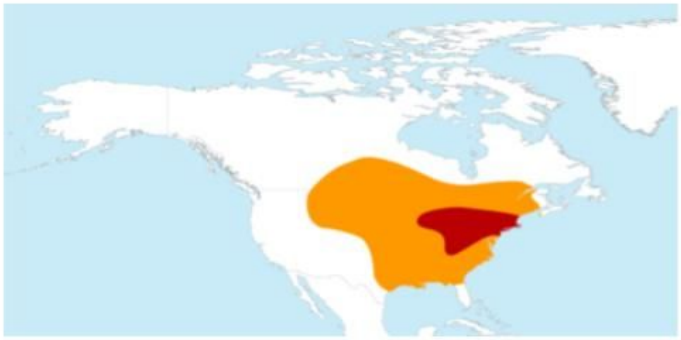
Martha in 2015

The Range of The Passenger Pigeon

The passenger pigeon was nomadic, constantly migrating (moving) in search of food, shelter, or nesting grounds.The passenger pigeon was found across most of North America east of the Rocky Mountains, coinciding with its primary habitat, the eastern deciduous forests. A communally roosting species, the passenger pigeon chose roosting sites that could provide shelter and enough food to sustain their large numbers for an indefinite period.

Food Web

The passenger pigeon changed its diet depending on the season. In the fall, winter, and spring, it mainly ate beech nuts, acorns, and chestnuts. The birds primarily ate the nuts of beech and oak trees during nesting times. During the summer, berries and softer fruits, such as blueberries, grapes, cherries, mulberries, pokeberries, and bunchberry, dominated its diet. It also ate worms, caterpillars, snails, and other invertebrates, particularly while breeding. It took advantage of cultivated grains, particularly buckwheat, when it found them.



Original Range of the Passenger Pigeon

Nesting colonies attracted large numbers of predators, including minks, weasels, and raccoons that preyed on eggs and nestlings, birds of prey, such as owls, hawks, and eagles that preyed on nestlings and adults, and wolves, foxes, bobcats, American black bears, and cougars that preyed on injured adults and fallen nestlings. Cooper's hawk was known as the "great pigeon hawk" due to its successes, and these hawks allegedly followed migrating passenger pigeons.

While many predators were drawn to the large concentration of birds, individual pigeons were largely protected due to the sheer size of the flock, and overall little damage could be inflicted on the flock by predation. Despite the number of predators, nesting colonies were so large that they were estimated to have a 90% success rate if not disturbed by humans.

An Ecosystem Engineer

The bird is believed to have played a significant ecological role in the make-up forests of eastern North America. For example, while the passenger pigeon was alive, forests were dominated by white oaks, because the birds preferred to eat the nuts from red oaks, especially during breeding season. Therefore, the red oak tree population was limited by the pigeon. The absence of the passenger pigeon's seed consumption may have contributed to the dominance of red oaks that we see now.

Due to competition, the presence of the passenger pigeon limited the populations of other seed-eating organisms. After the disappearance of the passenger pigeon, the population of one acorn feeding species, the white-footed mouse, grew exponentially because of the increased availability of the seeds of the oak, beech and chestnut trees. It has been speculated by some scientists that the extinction of passenger pigeons may have increased the prevalence of tick-borne lyme disease in modern times as white-footed mice are the reservoir hosts of the tick.

One important role passenger pigeons may have played was to create disturbance within the forest. With the large numbers in passenger pigeon flocks, the excrement (poop) they produced was enough to destroy some vegetation at long-term roosting sites, while adding high quantities of nutrients to the ecosystem. Additionally, the pigeons were thought to open up the canopy (top of the trees) by breaking the tree limbs they sat on,

allowing light to hit the forest floor. Their role in creating forest disturbances has been linked to greater diversity in forests by creating more niches for animals to fill. Due to these influences, some ecologists have considered the passenger pigeon a keystone species, with the disappearance of their vast flocks leaving a major gap in the ecosystem.

Value to Humans

The passenger pigeon played a religious role for some northern Native American tribes. The Wyandot people (or Huron) believed that every twelve years, the souls of the dead changed into passenger pigeons, which were then hunted and eaten. The Seneca people believed that a white pigeon was the chief of the passenger pigeon colony, and that a Council of Birds had decided that the pigeons had to give their bodies to the Seneca because they were the only birds that nested in big groups (or colonies). The Seneca developed a pigeon dance as a way of showing their gratitude.

The passenger pigeon was an important source of food for the people of North America. Native Americans ate pigeons, and tribes near nesting colonies would sometimes move to live closer to them. Many Native Americans were careful not to disturb the adult pigeons, and instead ate only the juveniles as they were afraid that the adults might desert their nesting grounds; in some tribes, disturbing the adult pigeons was considered a crime.

Making Sense of the Ecology of the Passenger Pigeon Investigation

Using your peers' model of the complex interactions between the pigeon and the physical and living parts of the ecosystem, complete the See-Think-Wonder table below.

See	Think	Wonder

Analysis Questions:

1. How did the model and the complex set of interactions it showed help you explain how this ecosystem remained stable?

2. Describe how humans were incorporated into your model

Ecology of the Passenger Pigeon Investigation Rubric

Student Rubric - Ecology of the Passenger Pigeon Investigation

How did you do in the investigation?

	Student Self-Score Select one		
I know how this investigation connects to our current unit.	No - I need help.	Almost	Yes
I was able to contribute to the See-Think-Wonder and / or respond to the analysis questions.	No- I need help.	Almost	Yes
I used my time well in this investigation.	No	Mostly	Yes
I plan to come in for extra help to complete parts of the investigation or ask questions.	No		Yes

What other resources could you have used to get more out of this investigation?

- More time
- More resources
- More information
- More help from my partners
- More help from my teacher
- Other:

Partner Rubric - Ecology of the Passenger Pigeon Investigation

How did your partners do in the investigation?

Directions: Think back to how your partners participated in the lab. For each of the four categories, write the name(s) of your partner(s) in the appropriate box.

	Unsatisfactory	Pretty Good	Excellent
Contributions	Did not participate.	Did the minimum of what was required.	Provided useful ideas when participating in discussion.
Working with Others	Rarely listened to others. Disrupted or discouraged others' attempts to participate.	Usually listened to, shared with, and supported the efforts of others.	Listened to, shared with, and supported the efforts of others.
Time Management	Procrastinated, did not use school time or schedule provided to get work completed.	Mostly used time well and completed investigation on time.	Used time well to ensure things get done on time.

Evaluating an Argument

Directions: Ben Novak is a scientist who is in charge of a project to bring back the passenger pigeon from extinction. He suggests that de-extinction work is important in addressing the extinction and biodiversity crisis. Evaluate his argument by identifying and then critiquing his claims, evidence, and reasoning. Use the spaces provided below to note down your ideas.

1. What claim(s) is he making?

2. What evidence is he using to support his claim(s)?

3. What additional evidence would strengthen the validity and reliability of the claim(s)?

4. What scientific reasoning is he using to support or explain the claim?

5. Assess the logic of the reasoning provided using your models of the passenger pigeon ecosystem, and your understanding of ecosystem functioning and dynamics.

6. Based on your prior knowledge, and learning from this unit, what counterclaims or might one make or concerns they would want to investigate before moving forward with this solution?

7. Using all of the above analysis, discuss the strengths and weaknesses of Ben Novak's proposed solution.

Summary Task

Today we completed a class consensus discussion. How did it go?

1. One thing that went well in the discussion:

2. One thing we can improve the next time we have a discussion:

3. One person who helped me learn today:

4. What did you learn from this person?

5. One idea that I contributed to my group or my class:

Explain what you know about the following questions, based on what we discussed today.

1. Based on the models you created and viewed, explain how the passenger pigeon played a role in the functioning and stability of its ecosystem.

2. Based on the evidence and scientific reasoning discussed in this learning cycle, discuss your understanding of how de-extinction **might** be helpful in addressing anthropogenic (human-caused) changes to the environment. Include reasons why it is important to consider solutions, such as de-extinction, to address the loss of biodiversity.

3. Discuss some of the strengths and weaknesses of Dan Novak's (and others) argument that de-extinction is a strong solution to the loss of biodiversity due to human's actions.

Read-Generate-Sort-Solve Graphic Organizer

Read - Generate - Sort - Solve

Read the prompt and the text silently.

Generate solutions/ideas:

Name: _____	**Name: _____**	**Name: _____**

Sort - Discuss each solution or idea and **star** the ideas that seem the most useful

Solve - Individually write your **response** to the prompt incorporating the most useful ideas from the sorting process!

Woolly Mammoth Argument

Bringing the Mammoth Back

US startup Colossal Biosciences aims to modify Asian elephant embryos using CRISPR gene editing technology to bring back extinct woolly mammoths. Therefore creating elephant-mammoth hybrids or "mammophants" that could be released into the Siberian tundra to fill the ecological niche that mammoths once occupied. The entire genome for the woolly mammoth has been sequenced from frozen specimens, so the genetic information is available for scientists to work from.

Mammoths likely had elaborate social systems similar to modern elephants, and are thought to have lived in groups of up to twenty individuals led by a matriarch (female leader). Groupings of mammoth bones at sites where multiple individuals died together show extended family structures. Preserved mammoth tracks show extended families walking side-by-side.

Ecosystem Engineers

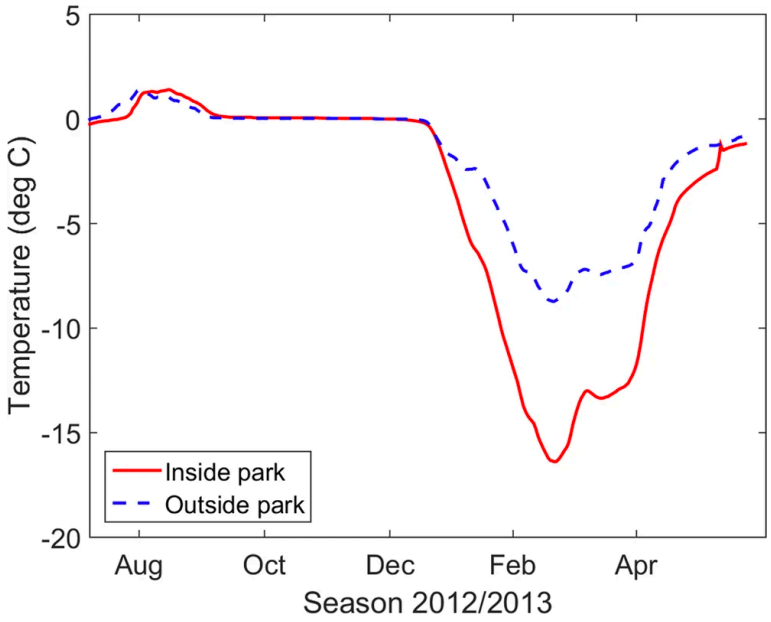
Some researchers have argued that woolly mammoths were ecosystem engineers, just as their close relatives, the elephants are. There is evidence that they maintained the grasslands by breaking up moss, knocking down trees and providing fertilizer with their droppings. Therefore, the loss of mammoths over the past 10,000 years has led to the disappearance of grasslands, or what is called a Steppe-Tundra ecosystem. Additionally, mammoths may have once scraped away layers of snow so that cold air could reach the soil and maintain the permafrost (frozen layer under the soil).

Fighting Climate Change

Grasslands, like the Steppe-Tundra that was maintained by the mammoths, are more efficient at absorbing carbon dioxide, than mossy forests and wetlands that increased in the region after the extinction of the mammoths. Additionally, the mammoths may have kept snow from accumulating. After they disappeared, the accumulated snow, with its insulating properties, meant the permafrost began to warm, releasing greenhouse gasses, some scientists contend. They argue that returning mammoths — or at least hybrids that would fill the same ecological niche — to the Arctic could reverse that trend. Some scientists argue that the reintroduction of the woolly mammoth would restore what is now a degraded ecosystem and bring back a richer tundra that existed 10,000 years ago.

Russian ecologists have imported bison and other living herbivores to a preserve in Siberia they've named Pleistocene Park, in the hopes of turning the ecosystem back to grassland. One way the grassland may help reverse climate change is to keep the permafrost from melting. The graph below demonstrates the change in soil temperature inside and outside the park.

Comparison of soil temperature observations (°C) at 90 cm depth inside and outside the Pleistocene Park, Kolyma river lowland, Russian Far East during one year.



Some argue that resurrected woolly mammoths would be able to do this more efficiently. The restored grassland would keep the soil from melting and eroding, and might even lock away heat-trapping carbon dioxide. Grazing by these hybrids would create a cycle that prevents the thaw and release of greenhouse gasses and allows grasslands to thrive, which would reflect the Sun's radiation and slow the melting of snow.

Love Dalén, a professor in evolutionary genetics at the Stockholm-based Centre for Palaeogenetics, is skeptical of that claim. He said, "I personally do not think that this will have any impact, any measurable impact, on the rate of climate change in the future, even if it were to succeed," "There is virtually no evidence in support of the hypothesis that trampling of a very large number of mammoths would have any impact on climate change, and it could equally well, in my view, have a negative effect on temperatures."

Other scientists argue that ethical objections should not relate to Colossal's aim to increase biodiversity, but rather to its means. One concern is that the de-extinction project could distract from more cost-effective efforts to protect biodiversity or mitigate climate change. The other relates to the possible ethical implications of genetic engineering and of bringing back extinct species.

Speaking with NPR in 2015, Beth Shapiro, a paleogeneticist at the University of California, Santa Cruz and author of How to Clone a Mammoth: The Science of De-Extinction, said emphatically, "I don't want to see mammoths come back." "It's never going to be possible to create a species that is 100% identical," she said. "But what if we could use this technology not to bring back mammoths but to save elephants?"

Other experts such as Joseph Frederickson, a vertebrate paleontologist and director of the Weis Earth Science Museum, express different concerns. He explained, "There is a new normal that has existed for thousands of years that has adapted to the continually changing climate. Bringing back something that has all the characteristics that would have thrived in the Pleistocene doesn't necessarily mean it's going to survive today, especially when you're mixing in the unknowns of other genes that are acting in a warm-weather tropical animal and then trying to move it to a new environment.There were plants and animals that were living alongside the mammoth that are now long gone or have drastically shrunk in their range, and just bringing back the mammoth won't bring those back."

Passenger Pigeon 5E - Mini Rubric

Component	Developing	Proficient

Strengths	Effectively and clearly outlines the strengths of the claim(s) evidence, and reasoning of the argument that includes **some** of the elements below:
	• The given evidence is outlined and how it supports the claim(s)
	• The utility of the given scientific reasoning of the argument is discussed in relation to:
	  ◦ Ecosystem stability/ resiliency
	  ◦ Human's role in disrupting ecosystems & biodiversity loss
	  ◦ How the solution address the problem of biodiversity loss (or loss of ecosystem function) or human caused disruptions/ destruction
	  ◦ How a range of constraints (cost, reliability, etc.) have been considered
		Effectively and clearly outlines the claim(s), evidence, and reasoning of the argument that includes **all** of the elements below:
		• The given evidence is outlined and how it supports the claim(s)
		• The utility of the given scientific reasoning of the argument is discussed in relation to:
		  ◦ Ecosystem stability/ resiliency
		  ◦ Human's role in disrupting ecosystems & biodiversity loss
		  ◦ How the solution address the problem of biodiversity loss (or loss of ecosystem function) or human caused disruptions/ destruction
		  ◦ How a range of constraints (cost, reliability, etc.) have been considered

Weaknesses	Effectively and clearly outlines the weaknesses of the claim(s), evidence, and reasoning of the argument that includes **some** of the elements below: • Identified additional evidence is used to assess the validity and reliability of the given evidence • The logic of the given scientific reasoning is assessed, and if appropriate – additional scientific reasoning is provided • If appropriate, an idea or concept is used to refute or question the claim(s) made in the argument	Effectively and clearly outlines the weaknesses of the claim(s), evidence, and reasoning of the argument that includes **all** of the elements below: • Identified additional evidence is used to assess the validity and reliability of the given evidence • The logic of the given scientific reasoning is assessed, and if appropriate – additional scientific reasoning is provided • If appropriate, an idea or concept is used to refute or question the claim(s) made in the argument

Student Self-Evaluation Circle one			**Teacher/Peer Evaluation** Circle one		
Evidence	Developing	Proficient	**Evidence**	Developing	Proficient
Reasoning	Developing	Proficient	**Reasoning**	Developing	Proficient
Evaluation	Developing	Proficient	**Evaluation**	Developing	Proficient
Glow			**Glow**		
Grow			**Grow**		

Unit Closing

Unit 6 Woolly Mammoth	Biology
Student Name:	

Biology Course Student Reflection

Directions: As the final unit in the course, it is important to pause and reflect on your own learning and growth as a science learner! Use the following prompts as inspiration, but feel free to reflect in your own way.

- What is something we did this year that you think you will remember for the rest of your life?
- What is something you accomplished this year that you are proud of?
- What was the nicest thing someone in our class did for you this year?
- What was the most challenging part of this year for you?
- If you could change one thing that happened this year, what would it be?
- What is something that was hard for you at the start of the year, but is easy now?
- In what area do you feel you made your biggest improvements?
- What is something you taught your teacher or classmates this year?
- What was the best piece of writing/modeling/design that you did this year? Why do you think it is your best?
- What advice would you give students who will be in this class next year?
- Considering all of your work throughout this year, which science and engineering practice or cross-cutting concept did you make the most progress on?
- How have your ideas on science or your role as a science knower/ learner changed this year?