Common Ancestry & Speciation

DEVELOPER: OpenSciEd

GRADE: High School **DATE OF REVIEW:** February 2024

equip
Educators Evaluating Quality Instructional Products

NextGen Science
WestEd

Common Ancestry & Speciation

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL RATING: E

TOTAL SCORE: 8

CATEGORY I: NGSS 3D Design Score	CATEGORY II: NGSS Instructional Supports Score	CATEGORY III: Monitoring NGSS Student Progress Score
2	3	3

Click here to see the scoring guidelines.

This review was conducted by the Science Peer Review Panel using the EQuIP Rubric for Science.

CATEGORY I CRITERIA RATINGS			CATEGORY II CRITERIA RATINGS			CATEGORY III CRITERIA RATINGS		
A.	Explaining Phenomena/ Designing Solutions	Extensive	**A.**	Relevance and Authenticity	Adequate	**A.**	Monitoring 3D Student Performances	Adequate
B.	Three Dimensions	Adequate	**B.**	Student Ideas	Extensive	**B.**	Formative	Adequate
C.	Integrating the Three Dimensions	Extensive	**C.**	Building Progressions	Adequate	**C.**	Scoring Guidance	Extensive
D.	Unit Coherence	Extensive	**D.**	Scientific Accuracy	Extensive	**D.**	Unbiased Tasks/Items	Adequate
E.	Multiple Science Domains	Extensive	**E.**	Differentiated Instruction	Adequate	**E.**	Coherent Assessment System	Extensive
F.	Math and ELA	Extensive	**F.**	Teacher Support for Unit Coherence	Extensive	**F.**	Opportunity to Learn	Adequate
			G.	Scaffolded Differentiation Over Time	Adequate			

Summary Comments

Thank you for your commitment to students and their science education. NextGenScience is glad to partner with you in this continuous improvement process. The unit is strong in several areas, including using an anchoring phenomenon to drive student learning and providing opportunities for students to develop key elements of the **Engaging in Argument from Evidence** Science and Engineering Practices (SEPs). Drawing from knowledge of the Inuvialuit community underscores the relevance of the polar bear phenomenon.

During revisions, the reviewers recommend paying close attention to the following areas:

- **Development of Three Dimensions**: The materials provide numerous opportunities for students to use elements of all three dimensions. This could be strengthened by providing more frequent opportunities for students to develop some of the claimed SEP and Crosscutting Concept (CCCs) elements that are not developed in the unit.
- **Differentiation**: The materials could be strengthened by providing increased differentiation strategies for multilingual learners and struggling readers as well as providing more detailed guidance for extensions.
- **Coherent Assessment System**: The materials contain numerous assessment types and opportunities. This could be strengthened by ensuring there's a match between elements claimed as developed or used and those claimed in assessment opportunities.

Note that in the feedback below, black text is used for either neutral comments or evidence the criterion was met, and purple text is used as evidence that doesn't support a claim that the criterion was met. The purple text in these review reports is written directly related to criteria and is meant to point out details that could be possible areas where there is room for improvement. Not all purple text lowers a score; much of it is too minor to affect the score. For example, even criteria rated as Extensive could have purple text that is meant to be helpful for continuous improvement processes. In these cases, the criterion definitely WAS met. The purple text is simply not part of the argument for that Extensive rating.

CATEGORY I

NGSS 3D DESIGN

I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

I.B. THREE DIMENSIONS

I.C. INTEGRATING THE THREE DIMENSIONS

I.D. UNIT COHERENCE

I.E. MULTIPLE SCIENCE DOMAINS

I.F. MATH AND ELA

I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

Making sense of phenomena and/or designing solutions to a problem drive student learning.

i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving.

ii. The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems.

iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.

Rating for Criterion I.A. Explaining Phenomena/Designing Solutions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that learning is driven by students making sense of phenomena and/or designing solutions to a problem because the materials are organized so that students are building an explanation around how the polar bear population has changed over time, and how changes to the Arctic climate may change them in the future. Student questions move the learning forward, as is documented using a Driving Questions Board (DQB).

The materials are organized so that students are figuring out a central phenomenon. Students regularly revisit the phenomenon throughout the unit. Related evidence includes:

- The introduction to the unit materials explains the anchoring phenomenon and why it was chosen. “In the anchoring phenomenon, students encounter the sighting of 3 bear species in one location in Canada for the first time, which may be related to the effect of climate change. Students investigate why all three bears may be adapted to the habitats in this area. They conduct a data exploration about changes to Arctic ice and tundra due to climate change and investigate how the 3 bear species could be affected by those changes. Students investigate the relationship between changing Arctic sea(sic) ice conditions and the stability of polar bear populations using both Traditional Knowledge and Western scientific sources. They develop initial models to predict how changes in Arctic ice conditions due to a warming climate may affect different polar bear populations in the future. They generate questions that they need to answer to be able to fully explain their models. The phenomenon was chosen because it gives students a real world[sic] context to investigate common ancestry, biological evolution, speciation and extinction and also provides a way to bring together what they figured out in past OpenSciEd units to consider the gravity of the problem and decide what, if anything, should be done to protect species from extinction. Students understand conservation, the effect of climate change on the Arctic, and connections between habitat fragmentation and evolution from previous units. The fate of the polar bear generated high student interest across racial and gender identities in a national survey” (Teacher Edition, page 10).
- Lesson 1: Students are introduced to the phenomenon of the three different types of bears meeting in the same area using pictures and videos. Students are asked to fill out a Notice and Wonder chart to document their observations and questions. Guidance is provided to teachers

for the types of questions which should be listened for. "Introduce the final unit of the year. Celebrate your classroom community's progress throughout the year using science and engineering practices, crosscutting concepts, and science ideas to figure out and explain biological phenomena. Display slide A. Introduce students to the phenomenon described on the slide. Photographs from one trail camera in Wapusk National Park captured images of a polar bear, brown bear, and black bear in the same location for the first time ever. Display slide B and ask students to set up a Notice and Wonder chart before showing https://youtu.be/PJoraSrB-QQ. Display slide C and ask a few students to share their noticings and wonderings" (Teacher Edition, page 25). A map is used to orient students to Wapuski — the location at which the three bears were sighted together.

- Lesson 2: "Say, We know that brown, black and polar bears are more likely to interact as the Arctic warms, especially in areas with seasonally available ice. Distribute Bear Interaction Claims. Ask students to work with a partner and construct a claim about how and why they think the different combinations of bear species will interact" (Teacher Edition, page 58).
- Lesson 2: Guidance is provided to connect what students have figured out to the phenomenon. "Reflect on what we figured out and what questions we have. Say, we were trying to figure out how and why bear species are interacting. We were really interested in figuring out why scientists think brown bears will dominate as the Arctic changes. Use the prompts below to summarize what we figured out and what we still need to know" (Teacher Edition, page 62).
- Lesson 2: The Progress Tracker is introduced in order for students to connect their learning to the phenomenon. "Propose starting a Progress Tracker to keep track of ideas. Display slide Y. Say, We have figured out a lot about polar bear thermoregulation and how that affects bear interaction. Let's capture what we have figured out in this lesson. Distribute Progress Tracker to each student and have students complete a row for Lesson 2" (Teacher Edition, page 66). Sample student responses are provided for the Tracker.
- Lesson 3: Students update their Progress Tracker. "Stop and jot in the Progress Tracker about what we figured out. Display slide M and give students a few minutes to record their ideas about what they figured out today. Call on a few students to share their ideas. Listen for the following ideas: There are eight species of bears that are all related to each other. Polar and brown bears are more closely related to each other than other bears. They probably have a common ancestor" (Teacher Edition, page 79).
- Lesson 4: "Say, You all wanted to know more about selection pressures and what might have been going on in the bears' environment. I have some data about ways the Arctic environment changed over geologic time that may help us figure this out" (Teacher edition, page 88).
- Lesson 4: "Motivate a return to the unit question. Display slide x. Celebrate students' accomplishment[sic] of writing and supporting a complex argument. Say, When we started this lesson, we said we needed to learn about the past to figure out the future for Arctic bears. Do we have enough information to do that now? Let's investigate this in the next class" (Teacher Edition, page 102).
- Lesson 6: The hybrid bear is introduced by using a quote from the Inuvialuit community. "Introduce new data from the Inuvialuit community. Say, I know some of you are concerned about polar bears and extinction and others wonder if the polar bears and brown bears might interact and mate. I found some very interesting data about instances where polar and brown bears have interacted in the wild. Display slide F and explain to students that the first piece of data comes from members of the Inuvialuit (In-oo-vee-Aloo-weet) that we heard from in Lesson 1. Read the quote to students. Then, ask students to turn and talk to a partner to interpret the quote. Call on a few pairs to share their ideas about what the quote tells them such as: People have seen polar and brown bears mating before. They have also seen half

breeds, half polar half brown bears and can recognize them" (Teacher Edition, page 119). Students are also provided a study by professional scientists. "Introduce a study of polar and brown bears that mated and produced offspring. Let students know that you have some additional data from a study published by scientists that you have summarized. Display slide G. Distribute Mating Between Bear Species to each student. Ask students to read on their own using whatever literacy strategy is in place in your classroom" (Teacher Edition, page 119).

- Lesson 6: "Introduce an investigation into whether polar bears can adapt to a warming climate. Say, One of the questions I heard you ask was about natural selection and if polar bears can adapt to the warming Arctic. Let's investigate that" (Teacher Edition, page 117).
- Lesson 7: "Explore current extinction data with a partner. Say, So we know some species that have gone extinct in the past, let's look into what species other than polar bears are in danger or are at risk of extinction. Let's find out more about other species" (Teacher Edition, page 128).
- Lesson 7: Students update Progress Trackers. "Update Progress Trackers. Display slide Y. Say, We have figured out a lot about patterns of past extinctions and discussed a bit about how this could impact our future. Let's capture what we have figured out in this lesson. Be sure to write down the questions our last discussion raises for you. Provide time for students to update Progress Tracker" (Teacher Edition, page 137).
- Lesson 8: "Discuss how scientists designate at risk species. Say, It sounds like we are starting to consider whether it makes sense to protect the polar bear and other species from extinction. To do that, we may need to have a better understanding of your other question about HOW people are doing this work already. Let's look at how people decide which species are at risk. Display slide B-D and explain how scientists and governments currently designate species as at risk for extinction. This will help us figure out which species to investigate" (Teacher Edition, page 144).
- Lesson 9: Students revisit the Progress Tracker. "Revisit Progress Trackers. Say, We figured out some new ideas in our last lesson. Display slide A and direct students to complete the four columns in this lesson row on Progress Tracker. An example Progress Tracker entry is provided below" (Teacher Edition, page 157).

Student learning is frequently driven by students' questions and ideas. However, there is little guidance provided for teachers to revisit student questions. Related evidence includes:

- Lesson 1: Students are prompted to ask questions following viewing of the different types of data throughout the unit and also after thinking about the classroom consensus model. Students then brainstorm additional questions after looking at the initial phenomenon and all data sets and use the questions to create a DQB. Teacher guidance is provided to guide students in brainstorming questions about the past and future polar bear populations.
- Lesson 1: "Generate ideas for investigation. Congratulate students on generating a productive board full of great questions. Let them know that the next step is to brainstorm ideas that will help us figure out how to answer those questions. Display slide SS. They should focus on one question at a time and generate ideas for how they could go about answering each question. Their first instinct may be to 'do research.' Prompt them to be more specific and answer questions about what specific data they would need to answer each question. Consider modeling an example to get them started. Give students two minutes to generate ideas for investigation in their science notebooks. Ask students to share their ideas and record them on a list on a whiteboard or chart paper titled 'Ideas for Investigation'" (Teacher Edition, page 48).
- Lesson 2: Students generate questions at the beginning of the lesson. "What have we figured out about polar, brown, and black bears? What questions do we still have about each of the

bears?" (Lesson 2 Slides, Slide A). A similar discussion of what has been figured out and what questions students have occurs at the beginning of most lessons.

- Lesson 2: Guidance is provided for students to share their prior knowledge about overheating and connect it to their own experiences. "Initial Ideas Discussion About Overheating. Display slide J and ask students to turn and talk to a partner about what happens when an animal overheats using their own personal experiences. Use the prompts below as a guide" (Teacher Edition, page 61). Some of the prompts provided include: "How do you keep yourself cool so you do not pass out?", and "What happens when you or other animals overheat?" (Teacher Edition, page 61).
- Lesson 4: "Brainstorm ideas about bear evolution. Say, I heard you say that natural selection may have occurred between the common ancestor in the past and the polar and brown bears in the present. In order for that to happen you identified genetic variation and selection pressures as necessary components. Display slide E. Encourage students to turn and talk with an elbow partner about the prompts. Suggest students look at the DQB for ideas as well" (Teacher Edition, page 87).
- Lesson 5: Students revisit the DQB. "Revisit the Driving Question Board. Say, It is important to take time to check in on our Driving Question Board questions so we can see the progress we have made toward answering them and use them to direct where we are going next in the unit. Display slide H and distribute DQB Questions[sic] to all students. Provide a few minutes for students to evaluate the DQB questions individually by marking them on DQB Questions[sic] using the key on the handout" (Teacher Edition, page 111). Students are provided with an opportunity to add new questions to the DQB.
- Lesson 9: Students revisit and close out the DQB. However, the incorrect question is referenced in the teacher materials. "Return to the Driving Question Board. Say, Now that we have had a chance to think about speciation and protecting a species from extinction, let's look back at our Driving Question Board. We have actually figured out a lot of things that we were wondering at the start of the unit that can help answer our unit question, What causes fires in ecosystems to burn and how should we manage them? Evaluate which questions from the Driving Question Board were answered. Display slide B. Have students take out DQB Questions[sic] from Lesson 5 and provide them with an updated version if you made one. Have students work in pairs for 5 to 10 minutes to mark questions they think the class has answered using the symbols on the handout, replicated here. Additionally, have students choose three questions to answer with evidence from their science notebooks. We did not answer this question or any parts of it yet: o Our class answered some parts of this question, or the ideas we developed help me see how I could now answer some parts of this question: ✓ Our class answered this question, or using the ideas we developed, I could now answer this question: ✓+" (Teacher Edition, pages 157–158).

Suggestions for Improvement

Consider providing opportunities for students to regularly revisit the DQB to add new questions that arise over the course of their learning.

I.B. THREE DIMENSIONS

Builds understanding of multiple grade-appropriate elements of the science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) that are deliberately selected to aid student sense-making of phenomena and/or designing of solutions.

i. Provides opportunities to *develop and use* specific elements of the SEP(s).

ii. Provides opportunities to *develop and use* specific elements of the DCI(s).

iii. Provides opportunities to *develop and use* specific elements of the CCC(s).

Rating for Criterion I.B. Three Dimensions	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found Adequate evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions because while there is a match between most elements claimed and used throughout the unit, there is some mismatch (particularly for CCC elements), and some focus elements are not fully developed within the unit.

Science and Engineering Practices (SEPs) | **Rating: Extensive**

The reviewers found extensive evidence that students have the opportunity to use or develop the SEPs in this unit because there is a strong match between elements claimed and used throughout the unit.

Asking Questions and Defining Problems

- *Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.*
  - This element is identified as key to sense-making in the unit.
  - Lesson 1: Students are prompted to ask questions following viewing of the different types of data throughout the unit and after thinking about the classroom consensus model. Students then brainstorm additional questions after looking at the initial phenomenon and all data sets and use the questions to create a DQB.

Developing and Using Models

- *Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.*
  - This element is identified as key to sense-making in the unit.
  - Lesson 1: Students individually develop initial models. "Develop initial models. Display slide JJ. Form groups of 3-4 and distribute a blank piece of chart paper and colored markers to each group. Have students draw a line through the center and give them 10 minutes to develop two models that explain what will happen to the populations of Arctic bears living in habitats with seasonally available vs. permanent ice as their environment changes. Suggest that groups list components, interactions, and mechanisms they want to include before they begin their models. Encourage the use of pictures, symbols, and/or words in their model to help represent and further explain their ideas. Prompt groups to consider factors related to climate change, habitat

change, and interactions with other bears as they develop models. Encourage students to record any questions that emerge for them as they develop their models. They will build a Driving Question Board at the end of the lesson and productive questions will likely arise while modeling. Explain that they will be sharing these models with their peers, so they should make sure ideas are labeled and explained clearly" (Teacher Edition, page 40). Students then post their models around the room and participate in a gallery walk in which they note similarities and differences between models. Students then engage in a discussion to create a classroom consensus model. The following suggested teacher prompts are provided: "What key components do we want in our model? ", and "What interactions do we want in our model?" (Teacher Edition, page 42). While students do model components of the system, there is not specific guidance to teachers or students to ensure that students look at relationships between these components.

- Lesson 5: Students construct "Gotta-Have-It Checklists" first in small groups and then as part of a whole class discussion in order to determining components which must be present in their model which will be used to answer the question "What will happen to Arctic bear populations as their environment changes?" (Teacher Edition, page 109). Students then revise the class consensus model. "Revise the class consensus model. Display slide F. Explain that now we can use our Gotta-Have-It Checklists to revise our class consensus model. Provide a minute for students to quietly consider how they would revise the model before you begin as a class. Then display slide G and facilitate the revision of the initial consensus model that includes the items on the Gotta-Have-It Checklist. One sample of a revised consensus model is shown below" (Teacher Edition, page 110). Specific guidance is not provided to ensure that students look at relationships between components of the system.
- Lesson 6: Students use a model of hybridization to explore how well suited the hybrid may be to their environment. Lesson 6: "Review the model instructions. Display slide L. Let students know you will organize them into small groups. With their group, they will put the brown and polar bear chips where they think they would be on the map. Then, they will pair up one brown bear and with one polar bear. For each mating they will flip a coin for each trait to determine which allele they have. They should notice that while they need to flip the coin for the brown bear, the polar bear has no variation for these traits. Since there is only one possibility they do not need to flip the coin for the polar bear. In Hybridization Model students will record the outcome for each mating by circling the allele they get for each brown bear. Then, they should describe how they think the offspring will express the trait. For example, if they have two copies of the same allele (homozygous) they will express the trait as written. If they have two different alleles (heterozygous) they will express an intermediate Phenotype" (Teacher Edition, page 120). Students use evidence to the model to make a claim about how well suited they believe the hybrid population will be to the new environment. While students do look at a model for an overall system, emphasis is not placed on how components of the system interact.

Engaging in Argument from Evidence

- *Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments*.
  - This element is identified as a focus element for development.
  - Lesson 9: The following question is provided on the transfer task: "Using the evidence you investigated throughout this task and what you have figured out in the unit,

evaluate each claim by doing the following in the table below: a) identify evidence that supports or refutes the claim[sic] b) explain why the evidence does or does not support the claim." (B.5 Lesson 9 Assessment Bumblebee Transfer Task)
  - While this is identified as a focus element in the unit, it is not developed during the learning sequence, and it is only found on the final unit assessment.
- *Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.*
  - This element is identified as a focus element for development.
  - Lesson 4: After gathering information about how the Earth changed during glacial periods, students make a claim to answer the question "How did polar and brown bears become different species?" (B.5 Lesson 4 Slides, Slide P). After having an opportunity to share their claim with another student to look for similarities and differences, the class engages in a discussion. "Facilitate a building understandings discussion. Arrange the class in a Scientists Circle and display slide Q. Ask a few students to share their claims and discuss how they are similar or different from their partner's. Write at least one student claim on the board to use during the discussion to demonstrate how to support and turn it into an argument during the discussion. Discuss the prompt on the slide. Listen for students to mention they need evidence and reasoning to support their claims to turn them into arguments. If necessary, ask what they need to prove or convince someone that their claim makes sense" (Teacher Edition, page 92). Students are asked to create an initial argument using a provided handout which contains a graphic organizer. "Construct an Initial Argument. Display slide R and distribute Developing an Argument to each student. Facilitate a discussion about how to build an initial argument using the graphic organizer on Developing an Argument. Students can add their claim to Part 1 of Developing an Argument. Discuss the evidence students have to support the sample claim written on the board. Demonstrate how to add that information to the evidence column on Developing an Argument. Students may need to refer to other handouts in their science notebook for evidence. Discuss how to add reasoning to the graphic organizer on Developing an Argument for each piece of evidence. Refer to the prompts below or Key Developing an Argument for sample entries using Day 1 evidence" (Teacher Edition, page 93). In addition to the graphic organizer, the following guidance for writing an argument is found on the handout: "Arguments should contain the following (not necessarily in the order shown): 1. Claim: Answer the question including both when, where and why you think this occurred. 2. Evidence: Describe what data you have to support each part of your claim. 3. Reasoning: Use science ideas to describe how the evidence supports your claim. Create a story that links the evidence to your claim using science ideas" (B.5 Lesson 4 Handout, Developing an Argument, page 1). After constructing their initial arguments, students look at fossil data and discuss whether or not the new evidence supports or refutes their argument. Students then revise their arguments. "Update evidence lists. Display slide X. Say, So it sounds like the fossil evidence was useful for supporting some of our arguments for why bears split and maybe gave some of us some ideas of how we might need to revise our arguments. Let's take a few minutes to revise Developing an Argument" (Teacher Edition, page 98). After looking at genetic data, students again update their claim and argument. The teacher guide provides significant scaffolding that assumes students are not familiar with developing arguments. However, the progression of this element indicates that students should already be familiar with this practice since Grades K–2.
  - Lesson 7: After viewing information about mass extinction events students are asked to write an initial argument individually with support from others in their small group.

"Write initial arguments. Display slide N and provide time for students to individually write their initial arguments on Part C of Extinctions Graphic Organizer. Encourage students to support the people in their group during this process" (Teacher Edition, page 131). After writing their responses, students are given a chance to reflect on their argument and then receive some peer feedback. A handout is provided to guide peer feedback which includes the following prompts: "Does the claim explain the main cause of mass extinctions on earth?", "Is the claim easy to understand?", "Do they provide a pattern of evidence?", "Does the evidence directly relate to the claim?", and "Does the reasoning connect the evidence to the claim?" (B.5 Lesson 7 Handout, Peer Feedback Rubric, page 1). Students are provided with an opportunity to revise their initial arguments. "Revise initial arguments. Say, I think we now have a better understanding of what caused mass extinctions in the past and the consequences for biodiversity. Let's spend some time revising our arguments. Display slide W and provide time for students to revise arguments based on the prompt. Point out the subtle change in the argument writing prompt and that they should make sure they are explaining how extinctions affect biodiversity and supporting this idea with additional evidence if necessary" (Teacher Edition, page 135).

- *Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations)*
    - This element is identified as a focus element for development.
    - Lesson 8: Students consider arguments for if we should save the polar bear from extinction. After answering the question as individuals, students are instructed to engage in a discussion in small groups. "Evaluate options for the polar bear in groups. Say, We are still forming our arguments for if we should save the polar bear from extinction and we did not have a chance to look at all of the options from the case studies yesterday. Display slide S. Explain that students will return to the same groups they worked with to create their poster. First[sic] they will share with the other half of their group what they figured out from the extinction prevention case studies. Students should be open to listening to what the other half of their group saw yesterday as it may sway the argument they wrote in the opening navigation. Once they finish sharing what they learned from the case studies, they can take turns sharing their arguments and then respectfully discuss if people should intervene to save the polar bear. As groups discuss, as needed prompt students with questions such as: Do the new solutions you heard about change your argument about what should be done? What evidence do you have that this would help/hurt the polar bears? What evidence do you have that this could maintain genetic diversity in the population? What makes this technique challenging to implement? Who would need to be involved to make this successful? Do your ethical concerns fit with the science ideas we have figured out?" (Teacher Edition, page 149). The following additional teacher guidance is found in the "Supporting Students in Engaging In Argument From Evidence" section in the margins: "Throughout the second and third day of this lesson, students evaluate different options for protecting species from extinction in order to develop a logical argument for whether people should intervene to protect polar bears from extinction. Explain that while there is no right answer to this question, students should still challenge one another to use scientific evidence to support their statements. They should also be encouraged to ask about relevant factors that may make it difficult to implement solutions, such as cost, space, time, technological capability, and ethical considerations. Remind students that in previous units such as Fires Unit and Natural Selection Unit they also made these

types of decisions based on who was involved in decision-making, and how challenging it is to meet the needs of all interest-holders" (Teacher Edition, page 149). Students then engage in the discussion as a large class. At the end of the lesson, students individually complete an Exit Ticket using the following prompt: "Complete the Extinction Prevention Argument explaining: Do you think people should make an effort to protect the polar bear from extinction? Choose at least 2 of the solutions from the extinction prevention case studies that you think would be most useful in preventing the extinction of the polar bear. ● Defend an argument for why we should or should not implement those solutions based on the science, constraints and/or ethical considerations" (B.5 Lesson 8 Slides, Slide U).
    - While this is identified as a focus element in the unit, students are not provided with sufficient opportunities to fully develop this element and use it in the learning sequence.
- *Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.*
    - Lesson 2: Students are supported in making a claim about bear interactions. "Make claims about possible bear interactions. Display slide B. Say, We know that brown, black and polar bears are more likely to interact as the Arctic warms, especially in areas with seasonally available ice. Distribute Bear Interaction Claims. Ask students to work with a partner and construct a claim ✱ about how and why they think the different combinations of bear species will interact. Reference the laminated Bear Adaptation poster from Lesson 1 to remind students of what they figured out already about the three species of bears. Encourage them to utilize readings and handouts in their science notebooks from Lesson 1 to support them. Call on a few pairs to share their predictions. At this point, predictions will vary widely" (Teacher Edition, page 58). The following additional teacher guidance is provided in the "Supporting Students in Engaging In Argument From Evidence" section in the margin: "Students make a claim based on evidence that reflects scientific knowledge, including technical and scientific information adapted for classroom use. The scaffolds provided in Bear Interaction Claims are designed to support students as they learn to identify both evidence that supports and refutes their claim and to use that evidence to provide reasoning. On day 2, students will further develop their use of the practice as they work with student generated evidence" (Teacher Edition, pages 58–59). The handout provided contains a table which scaffolds the making and supporting their claims by providing a table which asks students the following questions. "Make a claim. How and why will these bears interact in the Arctic as their environment changes? Consider where and when these interactions will take place", "Cite SUPPORTING evidence. What evidence supports your claim?", "Cite REFUTING evidence. What evidence does not support your claim?", "Revised Claim with reasoning. How does the evidence help you explain why and how the bears are interacting?", and "Reflect. Explain any evidence that is hard to reason with or does not support your claim" B.3 Lesson 2 Handout, Bear Interaction Claims, pages 1–2).
    - Lesson 2: Students conduct an investigation about thermoregulation. The last question on the accompanying handout asks students the following: "5. Make a claim supported by evidence to respond to the following: How and why will polar and brown bears interact in the Arctic as their environment changes? Consider evidence from scientific studies and your own investigations" (B.5 Lesson 2 Handout, Thermoregulation Investigation, page 2).

Obtaining, Evaluating, and Communicating Information

- *Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.*
    - This element is identified as key to sense-making in the unit.
    - Lesson 1: The following information is provided to teachers in the "Supporting Students In Obtaining, Evaluating, and Communicating Information" section in the margins: "Throughout this lesson, students are asked to compare, evaluate, and integrate information that comes from multiple sources, including NASA, the Inuvialuit, Canadian government, and peer-reviewed science publications. All sources contribute useful information that provides evidence to explain changes in Arctic ice and the status of polar bear populations, but they provide information at different scales and focus on different aspects of the system with varying degrees of completeness. Facilitate discussions that recognize both the usefulness of each source as well as the gaps or limitations. Putting the pieces together from all sources provides some answers but should raise additional questions and requests for more data to learn what is happening to polar bears in the Arctic" (Teacher Edition, page 34).
    - Lesson 1: Students are provided with a Comparing Polar Bear Populations handout to evaluate the different data sources they have looked at in the lesson and synthesize the data sources to begin answering the question: "What might the future look like for the different polar bear populations?" (Lesson 1 Handout, Comparing Polar Bear Populations, page 3). The following teacher guidance is also provided to prompt students in evaluating different sources of evidence: "It may be helpful to jump in to facilitate a discussion comparing the usefulness of both the Traditional Knowledge and Western science knowledge. The goal is not to value one type of information over another, but rather to understand the benefits and limitations of both. Two important distinctions include: The Inuvialuit explain information but from personal experience, memory, or stories told by people they know. Western scientists record similar data using tools and record observations. Both sources of information provide useful details. The Inuvialuit do not track precise population counts but recognize patterns from experience. Western scientists include population counts, but the data includes a margin of error because it is not possible to count every animal. The data from the Inuvialuit and convergent ice data tell similar stories" (Teacher Edition, page 38).
    - Lesson 3: The following question is found on the assessment which asks students to look at pictures to provide an explanation. "Can scientists use these two pictures to tell how closely these two species of honey bees[sic] are related? Yes, because body structures are coded by genes. So if they have similar body structures, then they have genes in common and are probably closely related. No, because scientists can never determine relatedness with physical structures. They can only use genetic information to find relatedness. Therefore, these pictures do not provide enough data. No, because these pictures only show individual bees instead of each species. Scientists would need to look at more pictures of each type of bee to determine if they are related. Yes, because the pictures show that the organisms have similar behavior. Therefore, they must be closely related" (B.5 Lesson 3 Answer Key, L3 Electronic Exit, pages 2–3).
- *Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.*

- This element is not claimed in the front matter of the materials and is not identified as a focus element or key to sense-making. The element is only claimed in the lesson front matter.
- Lesson 3: In a discussion, the class organizes and interprets data from a computer simulation and written bear cards to build a tree showing the relationship of different bear species. “What to look for/listen for in the moment: As students build and interpret the bear trees from DNA using the computer program (SEP 8.2), listen for: Empirical evidence about genetics used to create groups. (SEP 8.2; DCI: LS4.A.1; CCC 1.5) Explanations that the ongoing branching in trees built using DNA represents multiple lines of descent from a common ancestor. (SEP 8.2; DCI: LS4.A.1; CCC 1.5) Evidence from anatomical and behavioral data that led to similar or different conclusions than DNA data. (SEP 8.2; DCI: LS4.A.1)” (Teacher Edition, page 79).
- Lesson 8: Students read one of three case studies about species that are at risk of extinction and fill out a provided graphic organizer. “Introduce the investigation. Display slide E. Explain that you found some case studies of species that are at risk of extinction and have an overview of what is happening with each one. Distribute Research Notes Organizer and discuss how students will use this graphic organizer to integrate information from multiple sources. You will provide each group with the first reading, but they will be responsible for finding others to understand what is happening to prevent its extinction” (Teacher Edition, page 145). Students then use the Evaluating Information Checklist to begin finding other sources which can help them find the information needed on the graphic organizer. Guidance is provided for how students should use the checklist: “Discuss how to use Evaluating Information Checklist. Students can work in pairs or individually within their group to conduct research. Before they start adding information to Research Notes Organizer, however, they should use Evaluating Information Checklist to evaluate if the website or resource is one they should use. Discuss the explanations of each category at the bottom of the page and discuss examples of (un)reliable sources (e.g.[sic] sites created by a governmental science group, like NOAA, vs[sic] bloggers). Explain that some websites may not meet criteria for every item on the checklist, but may still be reliable. If students determine that the resource is reliable, they should write down the source citation on the next open row of Evaluating Information Checklist. Then they can return to Research Notes Organizer and fill in what they learn from that resource on the appropriate row, adding the number of that source to column 2” (Teacher Edition, page 146).

- *Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).*
  - This element is not claimed in the front matter of the materials and is not identified as a focus element or key to sense-making. The element is only claimed in the lesson front matter.
  - Lesson 8: “Create a poster to share information about: ● The main threat to the species ● The approach(es) people are taking to protect it ● Who is involved? ● What constraints are they working with? ● Can the species still evolve to survive into the future? ● What questions remain unanswered? *Include information in multiple formats to make it easy to read and provide evidence to back up your statements. *All group members should be prepared to explain the poster” (B.5 Lesson 8 Slides, Slide H).

Disciplinary Core Ideas (DCIs) | **Rating: Adequate**

The reviewers found adequate evidence that students have the opportunity to use or develop the DCIs in this unit because there is a match between most DCIs claimed and those developed and used in the materials. However, several claimed DCI elements are not fully developed in the unit.

LS1.A. Structure and Function

- *Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system*.
    - This element is identified as a focus element for development.
    - Lesson 2: Guidance is provided for students to share their prior knowledge about overheating and connect it to their own experiences. "Initial Ideas Discussion About Overheating. Display slide J and ask students to turn and talk to a partner about what happens when an animal overheats using their own personal experiences. Use the prompts below as a guide" (Teacher Edition, page 61). Some of the prompts provided include: "How do you keep yourself cool so you do not pass out?", and "What happens when you or other animals overheat?" (Teacher Edition, page 61). Students then watch a video about polar bears overheating and record notices and wonderings. After the video students add to their glossaries: "Update personal glossaries. Say, As you all have described the polar bear getting hot and finding ways to cool down you have described what scientists call thermoregulation. Display slide L. Pause to give students a moment to add this definition to their personal glossaries. Definitions may look like: how the body maintains a constant temperature" (Teacher Edition, page 61). Students then look at thermoregulation data. Students then conduct an investigation about thermoregulation. Students are also provided a reading about thermoregulation to support them in making sense of both their investigation and the phenomenon. After this is complete, the following teacher guidance is provided: "Define homeostasis. Display slide V. Say, we noticed that while the core body temperature goes up and down, the body works hard to keep the temperature in a certain range. We think that this range is important for the organism's survival. What we just noticed with polar bear body temperature is what scientists call homeostasis. A sample personal glossary entry for homeostasis may look like: homeostasis is the ability to maintain a steady internal state as external conditions change" (Teacher Edition, page 65). After a bundling understanding discussion, the following teacher guidance is also provided: "Update personal glossaries. Display slide X. Let students know that they have just described something called feedback mechanisms. When the polar bears cool themselves off they are regulating their bodies through negative feedback by trying to get back to their temperature set point. When they cannot cool off, they overheat and pass out. Scientists call that positive feedback. In this case the bear gets farther and farther away from the set point until there is a final outcome, heat exhaustion or passing out" (Teacher Edition, page 66).
    - While this identified as a focus element in the materials, students are not provided with sufficient opportunities to fully develop this element and use it in the learning sequence.

LS2.C. Ecosystem Dynamics, Functioning, and Resilience

- *A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.*
    - This element is identified as a focus element for development. It's not clear what parts of the element are intended to be the focus of the unit because the initial part of this element: "*A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem"* is struck through in the lesson level claims, but the unit overview materials claim the entire element as a focus element.
    - Lesson 1: "The average temperature in Canada has increased slowly (by more than one degree Celsius) since 1948. Sea ice changes seasonally, and the total amount has been declining over the last 40 years. The ice in the Hudson Bay is breaking up earlier every year (in mid-July in the 1980s; in late June by 2005). The tundra is greening in most parts of the Arctic and browning in a few places. The amount of sea ice in the Arctic goes up and down every year. There is less ice now in the Hudson Bay and over the whole Arctic than there was in 1980... How does the sea ice decline affect the polar bears? How does the decline in sea ice affect other animals that live in the Arctic or other components of the ecosystem? If the sea ice in Hudson Bay is breaking up earlier and earlier each year, how does that affect the polar bears who use the sea ice?" (Teacher Edition, pages 32–33).
    - While the element is claimed as a focus element, students are not provided with sufficient opportunities to fully develop this element and use it in the learning sequence.

- *Moreover, anthropogenic changes (induced by human activity) in the environment— including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.*
    - This element is identified as a focus element for development.
    - Lesson 1: Students discuss the question: "How are polar bear populations in different ecoregions affected by changes to Arctic sea[sic] ice?" (Teacher Edition, page 40). The lesson provides the teacher with a variety of responses expected from this discussion. "Ice is available for polar bears all year round (islands & convergent) or only in the winter (seasonal ice & divergent). When ice is available only in the winter (divergent and seasonal), there is some evidence of polar bear population decline, declining body condition and reproductive trends. (DCI LS2.C.2; CCC: 1.5) When ice is available all year long (islands & convergent), there is some evidence of polar bear population stability and/or increase, stable and/or increasing body condition and reproductive trends. (DCI LS2.C.2; CCC: 1.5) Population trend data was available for most populations and was useful in supporting claims. (SEP 8.3; DCI LS2.C.2) For the seasonal ice ecoregion, body conditions and reproductive trend data was useful because it was complete. For the other ecoregions, it was less useful because there was more uncertainty. (SEP 8.3; DCI LS2.C.2)" (Teacher Edition, page 42). Although there has been a brief mention of climate

change in the video, human-caused changes to the environment are not a focus of this part of the lesson.

- Lesson 5: Students engage in a discussion about how changes to the Arctic could affect the ecosystem. "Some of students' lingering questions may include: How quickly will changes to Arctic ice occur? Will polar bears on permanent ice recover again if another glacial period comes? Is there any way to protect polar bears from the effects of climate change? Do polar bears still have genes from their common ancestor that might protect them from climate change? Will black bear populations change if there are more brown bears? Will there be more trees?" (Teacher Edition, page 111). Later in the lesson, the following idea is indicated as something to look/listen for in the class consensus model: "Uncertainty about whether ice will melt more quickly in the future due to human-induced climate change compared to past glacial cycles. (DCI: LS2.C.2; LS4.C.4; CCC: 3.1) Uncertainty about the ability of polar bear species to evolve fast enough to adjust to climate change. (DCI: LS2.C.2; LS4.C.4; CCC: 3.1) Uncertainty about what will happen to the black bear populations. (DCI: LS2.C.2; LS4.C.4; CCC: 3.1)" (Teacher Edition, page 111).

LS4.A: Evidence of Common Ancestry and Diversity

- *Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.*
  - This element is identified as a focus element for development.
  - Lesson 3: Teacher guidance is provided to motivate students looking at DNA data. "Whole class discussion about genetics and relatedness. Say, You all have some ideas about the similarities and differences between the bears and how it might tell us something about relatedness, but we are not really sure what it all means. How else can we make sense of this. Listen for students to suggest we look at genes. Say, You already mentioned that they had the same gene. NOS3 but different versions/alleles of the gene. We already know a lot about genetics, let's see if we can use our understanding of genetics to get some ideas about what is happening. Display slide C. Ask students to discuss the prompts on the slide with a partner and then with the class" (Teacher Edition, page 74). In addition, the following follow-up questions are provided: "Can you think of other evidence that might suggest the bears are genetically similar? Elevate ideas about similar morphologies and physiologies", and "How might DNA be connected to showing how bears are related? Elevate ideas that DNA is heritable. Individuals will be more closely related if they have more similar DNA" (Teacher Edition, page 74). Students are lead through a discussion about how looking at similarities and differences in DNA can provide information about how closely related species are. Students then are provided with bear DNA sequences to analyze. "Examine bear DNA sequences. Display slide I. Say, It sounds like we have an idea of how to compare DNA sequences and show it as a tree. Let's look at some bear DNA collected by scientists. Organize students into small groups of 3-5. Distribute Bear DNA Sequences either in print or digitally. When providing a digital copy, make sure students do not have edit access to the file. Ask students to share their noticings with the class" (Teacher Edition, page 76). Students use this data to build a bear DNA tree.

- Lesson 3: The following question is found on the Electronic Exit Ticket. "Using the genetic data from above, how can patterns be used to explain the relatedness of the two species of honeybees? Not related because the patterns between each of the bars on the graph for both species are not the same, and the percentages of base pairs in the table are not the same. Related because of the similar patterns between each of the bee species compared to the fruit fly for both the graph and the data table. They are the same type of bee because the patterns in the genetic data are practically the same. These bee species just originated from different places. Not enough information to determine if these two species are related" (B.3 Lesson 3 Answer Key, L3 Electronic Exit, page 5).
- While portions of the DCI element related to amino acid sequences and embryological evidence are struck through in the lesson level claims, the unit overview materials indicate the entire element as a focus element. Specific opportunities for students to develop or use ideas related to amino acid sequences and embryological evidence are not found in the unit materials.

LS4.C: Adaptation

- *Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.*
    - This element is identified as a focus element for development.
    - Lesson 4: The class reviews their understanding of natural selection. "What mechanism causes populations to change and develop adaptations? *Evolution Natural selection.* What must be present in a population for evolution to occur? *Genetic variation within the population. Not all individuals in a population have the same gene variations.* What must be present in the environment for evolution to occur? *Selection pressures. Environmental factors that make it more difficult/easy for some individuals to survive over others.* How do populations evolve through natural selection? Members of a population compete for a limited amount of resources and some get more. *Some individuals outcompete others based on genetic variations they have and survive to reproduce and produce more offspring*" (Teacher Edition, page 87). While this identified as a focus element in the materials, this is the only lesson in which it is specifically claimed, and students review the element rather than develop it.
- *Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline — and sometimes the extinction — of some species.*
    - This element is identified as a focus element for development.
    - Lesson 1: The class develops a consensus model that includes factors that cause changes in the bear populations. "What to look for/listen for in the moment: Students revise their initial models to develop a class model (SEP 2.3) that includes the following: Predictions that climate change will continue to cause a change in Arctic sea[sic] ice in some areas and a greening of the tundra. (DCI: LS4.C.4; CCC: 2.2) Loss of Arctic sea[sic] ice in ecoregions with seasonally available ice, leaving less habitat for polar bears. (DCI: LS4.C.4; CCC: 2.2) A decline in the polar bear population in some regions in response to habitat changes. (DCI: LS4.C.4; CCC: 2.2) Expansion of ice-free habitat for brown and

black bears. An expansion of brown bear populations in response to warming temperatures and greening tundra" (Teacher Edition, page 47).
    - Lesson 4: Students look at data about the environment in historical bear ranges. The following prompts are provided for them to discuss: "What is the environment like today where brown and polar bears live?", and "What was the environment like in the past?" (B.5 Lesson 4 Slides, Slide H). Students then engage in a reading about glacial and interglacial periods. While reading, students are asked to consider the following questions: "What were the major environmental changes over the last 700,000 years? How might these cause selection pressures for bears? What do you wonder about this information?" (B.5 Lesson 4 Handout, Glacial and Interglacial, page 1). Students engage in an activity to simulate how bear populations may have moved as a result of glacial periods and engage in a discussion of the following questions: "What options do bears have in each location when the amount of ice changes? How would bears living in Greenland experience the changes differently from bears living in Wapusk/Canada/Europe? What selection pressures existed during that time in that location? How quickly did the climate change?" (Teacher Edition, page 91).
    - Lesson 5: The following idea is indicated as something to look/listen for in the class consensus model: "Brown bear populations will expand because climate change melts the ice earlier than before, increasing their available range and making more food available to them" (Teacher Edition, page 111).
    - Lesson 5: The following idea is indicated as something to look/listen for in the class consensus model: "Polar bear populations on seasonally available ice will decline because: They will overheat on land. They will interact more often with brown bears at food sources and lose" (Teacher Edition, page 111).
- *Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.*
    - This element is identified as a focus element for development.
    - Lesson 6: "Based on scientists' predictions of future ice conditions in the Arctic, how likely is it that polar bears will adapt to their changing environment? Please explain. It is unlikely that polar bears will adapt via natural selection because they have low genetic diversity and the change is happening really fast. Even under the most conservative conditions they only have about 5 generations to adapt and that is not a lot based on what we saw in the past. How many years/generations did it take for polar bears to evolve when the environment changed in the past? How does the past compare to the present/future? If it is not likely that polar bears will adapt via natural selection, what are the other possibilities for their future? They might go extinct" (Teacher Edition, page 119)
    - Lesson 8: "Create a poster to share information about: ● The main threat to the species ● The approach(es) people are taking to protect it ● Who is involved? ● What constraints are they working with? ● Can the species still evolve to survive into the Future?" (B.5 Lesson 8 Slides, slide N).
    - Lesson 9: The provided transfer task uses endangered bees and their effect on ecosystems as the driving phenomenon. However, specific understanding of this DCI is not essential to answer questions on the assessment.

LS4.D Biodiversity and Humans

- *Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).*
    - This element is identified as a focus element for development.
    - Lesson 7: Students engage in a discussion about how other species would be affected if polar bears were to go extinct. After this discussion, the following teacher guidance is provided: "Review the importance of biodiversity to ecosystem resilience. Display slide E and discuss the slide prompts. Listen for students to mention that an ecosystem with higher biodiversity can adjust and recover more easily from disturbances in the environment, like changes in rainfall patterns or small fires. Without the polar bear, the ecosystem will be less resilient and there could be harm to unexpected parts of the ecosystem in the future. Humans are part of these ecosystems" (Teacher Edition, page 128). Later in the lesson, students engage in a discussion connecting mass extinction to biodiversity. "Remind students that they saw images of marine life in each of these time periods when they looked at the Mass Extinction Visual Inquiry. Display slide V. Ask students what they notice about how life forms change after each extinction and discuss possible mechanisms for those differences. Listen for students to mention that there are different kinds of organisms after each extinction that look different. Listen for them to explain that depending on which species survive an extinction there is different genetic information available for evolution to work with. If entire families disappear, some life forms may be gone forever. Selection pressures from changed ocean environments may also cause species to evolve with different adaptations (change size, different ways of eating, etc.). Say, So we know that biodiversity returns after a mass extinction, but it does not always look the same" (Teacher Edition, page 135). While the idea of extinction causing a loss of biodiversity is addressed, the idea of speciation increasing biodiversity is not addressed.
    - While this identified as a focus element in the materials, students are not provided with sufficient opportunities to fully develop this element and use it in the learning sequence.

ESS2.E. Earth's Systems

- *The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it.*
    - This element is identified as a focus element for development.
    - Lesson 4: "Connect genetic information to glaciation maps. Say, Yesterday you developed initial arguments supporting a claim for what could have happened between a common ancestor in the past and polar and brown bears in the present. However[sic] we noticed that we were missing some evidence that needed to support our arguments. What additional evidence do we have now? Listen for students to mention fossil evidence and genetic evidence. Say, We have talked a little bit about how each of these pieces of evidence support or refute our arguments individually. Let's see if we can put all of the pieces we have together before we revise our arguments. Acknowledge the challenge of bringing together evidence from different spatial and temporal scales together to create a coherent argument. Explain that the students will use the same maps of glacial and interglacial periods that they used in the previous class, but this time you have added the genetic variations to the bear chips" (Teacher Edition, page 101).
    - Lesson 7: Students engage in a building understanding discussion about the cause of mass extinction events. The following guidance is provided for things to listen for in the discussion: "Earth's temperature warmed or cooled significantly with each mass

extinction. Increases or decreases in atmospheric carbon dioxide levels contributed to the warming or cooling in most of the mass extinction events. Most mass extinctions affected marine life" (Teacher Edition, page 138).

ETS1.B Developing Possible Solutions

- *When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.*
    - This element is identified as a focus element for development.
    - Lesson 8: After reading case studies about what is being done to help save some species, students begin discussing if they should help save polar bears, and if so, what techniques should be used. In this discussion students are asked to think about what constraints they should consider. At the end of the lesson, students individually complete an Exit Ticket using the following prompt: "Complete the Extinction Prevention Argument explaining: Do you think people should make an effort to protect the polar bear from extinction? Choose at least 2 of the solutions from the extinction prevention case studies that you think would be most useful in preventing the extinction of the polar bear. ● Defend an argument for why we should or should not implement those solutions based on the science, constraints and/or ethical considerations" (B.5 Lesson 8 Slides, Slide U).

Crosscutting Concepts (CCCs) | **Rating: Adequate**

The reviewers found adequate evidence that students have the opportunity to use or develop the CCCs in this unit. While there is some match between CCC elements claimed and used, there is also some mismatch. In addition, many focus elements are not developed in the materials.

Patterns

- *Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.*
    - This element is identified as a focus element for development.
    - Lesson 7: The following prompt is found on the student handout: "1. What patterns did you notice in the evidence across the extinctions in terms of causes and effects?" (Lesson 7 Handout, Extinctions Graphic Organizer) "–In each event something happened that caused rapid heating or cooling of the atmosphere. In 4 of 5 cases changes to carbon dioxide levels from volcanic activity, photosynthesis or erosion were responsible for the change in temperature. –Each cause (volcanic activity, photosynthesis, asteroid, or erosion) also changed the chemistry of the ocean, which killed marine life. –At least 75% of species died in each mass extinction, a huge drop in biodiversity" (Lesson 7: Answer Key). However, there is no specific connection made between the patterns and the scale at which they are observed.
- *Empirical evidence is needed to identify patterns.*
    - This element is identified as a focus element for development.
    - Lesson 1: Student analyzer data from a variety of sources to find patterns in polar bear populations in different areas. However, specific guidance for students building understanding of empirical evidence being needed to identify patterns is not given.
    - Lesson 3: Students look for similarities and differences in DNA to determine relationships between types of bears. The following look for is provided in the

assessment opportunity section of the materials: "Empirical evidence about genetics used to create groups" (Teacher Edition, page 79). However no specific guidance is provided to students to support them building an understanding of the importance of empirical evidence for identifying patterns.
- Lesson 3: The following question is found on the Electronic Exit Ticket: "Using the genetic data from above, how can patterns be used to explain the relatedness of the two species of honeybees? Not related because the patterns between each of the bars on the graph for both species are not the same, and the percentages of base pairs in the table are not the same. Related because of the similar patterns between each of the bee species compared to the fruit fly for both the graph and the data table. They are the same type of bee because the patterns in the genetic data are practically the same. These bee species just originated from different places. Not enough information to determine if these two species are related" (B.3 Lesson 3 Answer Key, L3 Electronic Exit, page 5). While students do find patterns in the data, the role of empirical evidence is not addressed.

Cause and Effect

- *Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.*
    - This element is identified as key to sense-making in the unit.
    - Lesson 1: Students make an initial model to predict how changes to the environment may affect the polar bear population. However, smaller scale mechanisms are not specifically explored.
    - Lesson 6: Students look at how individual traits are passed on within polar bears to predict what effect changing conditions in the Arctic will have on hybrid offspring and predict what effect they believe that will have on future generations. "In Hybridization Model students will record the outcome for each mating by circling the allele they get for each brown bear. Then, they should describe how they think the offspring will express the trait. For example, if they have two copies of the same allele (homozygous) they will express the trait as written. If they have two different alleles (heterozygous) they will express an intermediate Phenotype" (Teacher Edition, page 120). However, there are no student prompts that focus thinking on the cause and effect relationship.
- *Changes in systems may have various causes that may not have equal effects.*
    - This element is identified as key to sense-making in the unit.
    - Lesson 2: Students consider how thermoregulation may be different in humans and polar bears. "What does the class data tell us about how human body temperature changes during exercise? Human body temperature stays relatively constant during exercise. We sweat and breathe hard to get rid of excess heat. How is it similar or different to what we saw in the polar bear treadmill study? Polar bear temperature went way up during exercise. What explains the difference between humans and polar bears? Polar bears have adaptations like thick fur and fat that keep them from losing heat and they are not good at sweating. Polar bears have an allele that makes them make less cellular energy and more heat from cellular respiration" (Teacher Edition, page 65).

Scale, Proportion and Quantity

- *The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.*
    - This element is identified as a focus element for development.
    - Lesson 1: The following guidance is provided in a "Supporting Students In Developing and Using Scale, Proportion, and Quantity" section: "to provide additional guidance as students are lead through looking at maps at different scales to examine the different habitats in Wapusk, students develop their use of the crosscutting concept scale, proportion, and quantity (with a focus on scale) in this unit. As students move between different map projections, ask them to reflect on what spatial information becomes significant as they zoom in or out with the different maps. They will also begin to notice how shifts in time scale reveal different information. At first, they will focus on significant times of year for particular bear activities related to the seasons. Later in the lesson, students will notice that as they look at seasonal data over many years, what might be expected to be a predictable pattern of seasonal change slowly shifts over many decades, increasing the significance of that longer-term data for the well-being of bear populations" (Teacher Edition, pages 26 and 27). The CCC elements are addressed later in the unit with further discussion about the significance of scale: "Discuss the significance of scale. Discuss the remaining prompts on slide K. Listen for students to mention that the maps are different in winter and summer and that the bears are not always in the same location. Say, It seems to be important for us to discuss not only where the bears are but also when. We need to pay attention to both space and time. The crosscutting concept scale, proportion, and quantity can help us think about this. Encourage examples from multiple science domains and questions for further investigation. Use the prompts below as a guide" (Teacher Edition, page 27). The provided prompts include: "How is scale important to understanding what is happening with these bears?", and "Can you think of any other times it was important to pay attention to both space and time to understand a phenomenon?" (Teacher Edition, pages 27–28).
    - Lesson 1: Guidance is provided for the teacher to motivate looking at data and the use of **Scale, Proportion, and Quantity**. "Frame a data exploration. Display slide L. Say, Great questions! Some of you mentioned that the permafrost is thawing in the Arctic and that you know the ice is also melting due to climate change" (Teacher Edition, page 28). The following teacher prompts are provided: "What type of data would help us understand the effect of climate change in Wapusk?" , "How would the scale of our investigation shift if we want to understand the impact of climate change?" (Teacher Edition, page 29). The use of the Scale Organizer handout provides a scaffold for students thinking around this CCC element by providing timelines in which to record their observations. After students record information the following teacher prompt is provided to help guide the class discussion: "How does changing the scale of the data change the trend we notice?" (Teacher Edition, page 31). The following follow-up questions are provided: "What time scale is important? (Are we concerned about seasonal change, human caused climate change, or geologic cycles?)", "Are we concerned about individual bears, populations, or whole species? (Are we interested in genetics, behaviors, evolution, or speciation?)", and "What spatial scale is important? (Are we concerned about resource availability and adaptations in one habitat, an ecoregion, or all of the Arctic?)" (Teacher Edition, page 108).
    - Lesson 5: Students engage in a class discussion about scale using the following teacher prompt: We need to consider multiple scales at one time. We need to think about where the environment is changing and over what time period. We need to understand

how bears are adapted to their habitats and seasonal changes that normally occur. We need to think about genetics and how it allows individuals to survive, but that adaptations can only evolve if there is genetic variation within the population. We need to think about how long it takes for populations to evolve if the environment changes." (Teacher Edition, page 108).
    - Lesson 9: The following questions are found on the lesson transfer task: "b) What does graph B tell you about the scale and/or significance of pesticide use? c) Some scientists claim that bee mortality has increased as pesticide use has increased because bees did not have time to adapt. Based on the evidence provided, i. What possible reasoning would scientists use to explain this claim? ii. What additional evidence would strengthen the claim?" (B.5 Lesson 9 Assessment, Bumblebee Transfer Task).
- *Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.*
    - Lesson 4: Students engage in a discussion about the challenges in gathering data about the common ancestor between polar bears and brown bears. The following teacher prompts are provided: "How does the crosscutting concept of scale apply to our question about the split of the bears?", and "Why could it be challenging to find data?" (Teacher Edition, page 88). As a result of these prompts, students discuss the challenge in studying the phenomenon directly and generate a need to find another method of studying indirectly.

Systems and System Models
- *Systems can be designed to do specific tasks.*
    - Lesson 8: At the end of the lesson, students individually complete an Exit Ticket using the following prompt: "Complete the Extinction Prevention Argument explaining: Do you think people should make an effort to protect the polar bear from extinction? Choose at least 2 of the solutions from the extinction prevention case studies that you think would be most useful in preventing the extinction of the polar bear. ● Defend an argument for why we should or should not implement those solutions based on the science, constraints and/or ethical considerations" (B.5 Lesson 8 Slides, Slide U).

Stability and Change
- *Much of science deals with constructing explanations of how things change and how they remain stable.*
    - Lesson 8: Students look at case studies about species which are endangered. While ideas of stability and change are present in the readings, there are no specific teacher or student prompts which directly address this SEP element.

Suggestions for Improvement

Science and Engineering Practices
- Consider providing increased opportunities for development of focus SEP elements. For example, the element "*Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments*" is identified as a focus element but is only found on the final unit assessment.
- Consider providing opportunities to make counter arguments.

- While the element "*Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence"* is not identified as a focus element for development in the unit, students are supported in its development in the unit. Consider identifying this element as a focus element.

Disciplinary Core Ideas
- Consider revising claims so that parts of DCI elements that are not addressed are struck through at the unit level and there is a clearer distinction between elements which are fully developed and those which are reviewed and/or used from prior learning.

Crosscutting Concepts
- Consider providing increased teacher prompts and language which specifically call out CCC thinking. Prompts which specifically address the language related to the elements would strengthen the development of these CCC elements (ex. specially providing prompts which ask students to provide empirical evidence for patterns).

I.C. INTEGRATING THE THREE DIMENSIONS

Student sense-making of phenomena and/or designing of solutions requires student performances that integrate elements of the SEPs, CCCs, and DCIs.

Rating for Criterion I.C. Integrating the Three Dimensions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found Extensive evidence that student performances integrate elements of the three dimensions in service of figuring out phenomena and/or designing solutions to problems because there are multiple opportunities which require students to use grade-level elements of all three dimensions.

Throughout the unit, there are numerous opportunities for students to use grade-level elements of all three dimensions in service of sense-making. Related evidence includes:
- Lesson 2: Students make claims about how the different types of bears interact and look at several pieces of information (readings, data sets, and information from an investigation) to support their claims about the causes of the interactions. Students integrate the following elements:
  - DCI: **LS1.A. Structure and Function** (Identified as a Focus DCI) *Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system*. (Identified as a focus element)

- SEP: **Engaging in Argument From Evidence** *Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.*
- CCC: **Cause and Effec**t *Changes in systems may have various causes that may not have equal effects.*

- Lesson 3: Students look at similarities and differences in DNA sequences to construct a tree showing the relationships between different types of bears. Students are asked how this compares to their thinking from data related to anatomical and behavioral traits looked at previously. Students integrate the following elements:
  - DCI: **LS4.A: Evidence of Common Ancestry and Diversity** *Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.*
  - SEP: **Obtaining, Evaluating, and Communicating Information** *Compare, integrate, and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.*
  - CCC: **Patterns** *Empirical evidence is needed to identify patterns.*
- Lesson 4: Students look at a variety of data sources, including how the Earth changed during glacial periods, to construct an argument for how they believe Polar Bears evolved.
  - DCI: **LS4.C: Adaptation** *Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverges under different conditions, and the decline — and sometimes the extinction — of some species.*
  - DCI: **ESS2.E. Earth's Systems** *The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it.*
  - SEP: **Engaging in Argument From Evidence** *Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. competing design solutions based on jointly developed and agreed-upon design criteria*.
  - CCC: **Scale, Proportion and Quantity** *Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.*
- Lesson 8: At the end of the lesson, students individually complete an Exit Ticket using the following prompt: "Complete the Extinction Prevention Argument explaining: Do you think people should make an effort to protect the polar bear from extinction? Choose at least 2 of the solutions from the extinction prevention case studies that you think would be most useful in preventing the extinction of the polar bear. ● Defend an argument for why we should or should not implement those solutions based on the science, constraints and/or ethical considerations" (B.5 Lesson 8 Slides, Slide U).
  - DCI: **ETS1.B Developing Possible Solutions** *When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts*.
  - SEP: **Engaging in Argument From Evidence** *Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).*

- CCC: **Systems and System Models** *Systems can be designed to do specific tasks.*

Suggestions for Improvement
N/A

I.D. UNIT COHERENCE

Lessons fit together to target a set of performance expectations.

i. Each lesson builds on prior lessons by addressing questions raised in those lessons, cultivating new questions that build on what students figured out, or cultivating new questions from related phenomena, problems, and prior student experiences.
ii. The lessons help students develop toward proficiency in a targeted set of performance expectations.

Rating for Criterion I.D. Unit Coherence	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found Extensive evidence that lessons fit together coherently to target a set of Performance Expectations (PEs) because lessons build directly on prior lessons using a variety of methods. Lessons are sequenced in a way that students see what they have figured out and what they have to figure out next. Students are provided with opportunities to build proficiency toward a targeted set of PEs.

Each lesson builds directly on prior lessons and the links between lessons are made clear to students using a variety of strategies, including providing students with opportunities to ask their own questions using what students figure out as the next question to pursue, and answering questions generated by students in the previous lessons. Related evidence includes:

- Lesson 1: "Students prioritize what question(s) to answer next. Display slide TT. Say, We have a lot of questions that we want to try and find the answers to during our last unit. We also have a great list of ideas for how to investigate those questions. Remind the class of the unit question, What will happen to Arctic bear populations as their environment changes? Ask students to review the DQB and their initial ideas for investigation with the unit question in mind. After a minute, ask students to share what question they think the class should investigate next. As students identify specific questions or groups of questions, keep a record of which questions the class thinks should be answered next. Prompt students to consider what aspects of their models are the most incomplete and increasingly motivated to understand the mechanisms better. They might think about which types of data or information would be more readily available to begin. Push students to justify their choices with reasoning for why answering that question first would be best. Encourage students to connect their reasoning to the broader unit question. Ask students to complete an exit ticket. Display slide UU. Ask students to tear out a half sheet of loose-leaf paper and, based on the DQB and ideas for investigation everyone just shared, write down their ideas for what the class should investigate next and why conducting that investigation would help the class make progress on the unit question" (Teacher Edition, page 49).

- Lesson 2: "Navigate. Display Slide A. Say, We started this unit looking at three bear species that were seen by scientists in the same location for the first time. Ask students to share their ideas with an elbow partner as they discuss the questions on the slide. Note that in the camera images on the slide, the bears look bigger or smaller depending on how far they are from the camera. A scale drawing is included to help students think about the average size of bears of each species. After a few minutes, have a few pairs share with the class" (Teacher Edition, page 58). The following prompts are provided to connect prior learning to learning in this lesson: "What have we figured out about polar, brown, and black bears?", and "What questions do we still have about each of the bears?" (Teacher Edition, page 58).
- Lesson 3: The lesson begins by having students discuss the following prompts to connect the previous lesson to upcoming learning. "What did we figure out in our last class?", and "What new questions did we have?" (Teacher Edition, page 73). Students' discussion of these prompts leads directly to the new learning. "Orient students to similarities and differences between bear species. Say, Great summary. Yesterday we ended with some new questions about how similar/different the bears are. Before we dive into the questions you have about their genetics, let's revisit some of what we already know to see if we can organize what we know about the bears' similarities and differences" (Teacher Edition, page 73).
- Lesson 4: The lesson begins by having students discuss the following prompts to connect the previous lesson to upcoming learning. "What did we figure out about the history of the bear family?", and "What were we wondering at the end of the last lesson?" (Teacher Edition, page 86).
- Lesson 4: Guidance is provided for motivating students to look at Arctic climate data: "Introduce geologic Arctic climate data. Say, You all wanted to know more about selection pressures and what might have been going on in the bears' environment. I have some data about ways the Arctic environment changed over geologic time that may help us figure this out. Review the map on slide H as a class. Give students a few minutes to consider the questions on the slide, then call on a few students to share their ideas using the prompts below as a guide" (Teacher Edition, page 88).
- Lesson 4: "Motivate a return to the unit question. Display slide x. Celebrate students' accomplishment of writing and supporting a complex argument. Say, When we started this lesson, we said we needed to learn about the past to figure out the future for Arctic bears. Do we have enough information to do that now? Let's investigate this in the next class" (Teacher Edition, page 102).
- Lesson 5: "Navigate to today's work. Direct student attention to the class consensus model. Say, We have figured out a lot since we first created our class consensus model in Lesson 1. Display slide B and discuss progress the class has made so far in answering the unit question, What will happen to Arctic bear populations as their environment changes? Use the following prompts as a guide" (Teacher Edition, page 107). The prompts provided include: "What does our current model explain?", and "What new ideas might we need to add to our model?" (Teacher Edition, page 107).
- Lesson 5: After making new questions for the DQB, the following teacher prompt is provided to connect to the next lesson: "Summarize new DQB questions. Say, It sounds like we are still concerned about the future of the polar bears and want to know more about their ability to adapt and survive in the future. Let's look into that next time" (Teacher Edition, page 112).

- Lesson 6: Students begin the lesson by engaging in a discussion about what they have figured out and what questions they still have. The following teacher guidance is provided to connect this discussion to upcoming learning: "Introduce an investigation into whether polar bears can adapt to a warming climate. Say, One of the questions I heard you ask was about natural selection and if polar bears can adapt to the warming Arctic. Let's investigate that" (Teacher Edition, page 117).
- Lesson 7: "Share questions and motivate a discussion about taking action to prevent extinction. Display slide Z. Ask a few students to share the questions they wrote in their progress tracker to help the class consider what to study next. Motivate the students to discuss whether action should be taken to prevent extinctions" (Teacher Edition, page 138).
- Lesson 7: "Motivate investigation into past extinction events. Say, We have seen evidence that extinction rates are higher now than before the Industrial revolution and some of us are worried about what the future holds. We know that extinctions have happened way in the Earth's past with the dinosaurs. Since looking at the past helped us think about the future before, let's take some time to look into Earth's past again to see what happened with extinction rates well before the Industrial Revolution" (Teacher Edition, page 130).
- Lesson 7: The following prompt is discussed as a class to motivate the need for more evidence: "What information does your group still need to strengthen your argument?" (B.5 Lesson 7 Slides, Slide O).
- Lesson 9: "Revisit Progress Trackers. Say, We figured out some new ideas in our last lesson. Display slide A and direct students to complete the four columns in this lesson row on Progress Tracker" (Teacher Edition, page 157).

The lessons build coherently to develop some of the targeted set of PEs. While some PEs are not fully developed within the unit, the front matter of the unit materials indicate that the identified PEs are "built toward" (Teacher Edition, page 10).

- **HS-ESS2-7:** *Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.*
    - Lesson 4: Students look at a variety of data sources, including how the Earth changed during glacial periods, to construct an argument for how they believe Polar Bears evolved.
    - Lesson 7: Students write an argument to explain the main cause of mass extinctions,
- **HS-LS1-3:** *Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.*
    - Lesson 2: Students conduct an investigation about thermoregulation in order to connect their data to how polar bears regulate body temperature.
- **HS-LS2-6:** *Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.*
    - While this PE is claimed to be developed in this unit, specific examples of development were not found.
- **HS-LS2-7:** *Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*
    - Lesson 8: At the end of the lesson, students individually complete an Exit Ticket using the following prompt: "Complete the Extinction Prevention Argument explaining: Do you think people should make an effort to protect the polar bear from extinction? Choose at least 2 of the solutions from the extinction prevention case studies that you think would be most useful in preventing the extinction of the polar

bear. ● Defend an argument for why we should or should not implement those solutions based on the science, constraints and/or ethical considerations" (B.5 Lesson 8 Slides, Slide U).

- **HS-LS4-1:** *Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.*
    - Lesson 3: Students look at similarities and differences in DNA sequences to construct a tree showing the relationships between different types of bears. Students are asked how this compares to their thinking from data related to anatomical and behavioral traits looked at previously.
- **HS-LS4-2:** *Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.*
    - Lesson 4: The lesson begins with a review of natural selection: "Review natural selection. Say, We are trying to figure out how a common ancestor bear population split into the two separate species they are today. We know that polar and brown bears have different adaptations to their environment. If they had a common ancestor something must have happened to cause the common bear populations to change. What do we already know about what can cause populations to change over time? Display slide C. Provide time for students to discuss the prompts with an elbow partner. If you have the class consensus model from Natural Selection Unit display it in a prominent place in the classroom to aid in discussion. Encourage students to review the Progress Tracker and other materials in their science notebook from Natural Selection Unit to remember the specific components of evolution by natural selection. Bring the class back together and display slide D. Facilitate a review of the model of evolution by natural selection" (Teacher Edition, page 86). The following teacher prompts are provided to guide the discussion: "What mechanism causes populations to change and develop adaptations?", "What must be present in a population for evolution to occur?", "What must be present in the environment for evolution to occur?", and "How do populations evolve through natural selection?" (Teacher Edition, pages 86–87).
- **HS-LS4-4:** *Construct an explanation based on evidence for how natural selection leads to adaptation of populations.*
    - Lesson 4: Students look at a variety of data sources, including how the Earth changed during glacial periods, to construct an argument for how they believe Polar Bears evolved.
- **HS-LS4-5:** *Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.*
    - Lesson 4: Students create a class consensus model to explain what might happen to polar bears in the future.
    - Lesson 7: Students write an argument to explain the main cause of mass extinctions.

Suggestions for Improvement

- Continue providing more specific teacher guidance outlining which PEs are intended to be fully developed within the unit.
- Consider removing the **HS-LS2-6** PE from the list of claimed PEs in the unit since development towards this PE is not present in the materials.

I.E. MULTIPLE SCIENCE DOMAINS

When appropriate, links are made across the science domains of life science, physical science and Earth and space science.

i. Disciplinary core ideas from different disciplines are used together to explain phenomena.

ii. The usefulness of crosscutting concepts to make sense of phenomena or design solutions to problems across science domains is highlighted.

Rating for Criterion I.E. Multiple Science Domains	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive Extensiveevidence that links are made across the science domains when appropriate because connections are explicitly made between Earth and life science domains as students make sense of the phenomenon. However, connections across these domains using grade-appropriate elements of CCCs are not frequently present.

Students connect Earth science concepts to life science concepts in order to fully make sense of the polar bear phenomenon. Related evidence includes:

- Lesson 1: Students look at a variety of data to determine how the change in environment has affected the bear population. Students use this information to build a class consensus model. During the discussion, the following suggested prompts are provided: “What mechanisms do we know that allow polar bear populations to adapt or change?” and “What has to happen for a population to evolve and adapt?” (Teacher Edition, page 43).
- Lesson 4: Students look at data about the environment in historical bear ranges. The following prompts are provided for them to discuss: “What is the environment like today where brown and polar bears live?” and “What was the environment like in the past?” (B.5 Lesson 4 Slides, Slide H). Students then engage in a reading about glacial and interglacial periods. While reading, students are asked to consider the following questions: “What were the major environmental changes over the last 700,000 years? How might these cause selection pressures for bears? What do you wonder about this information?” (B.5 Lesson 4 Handout, Glacial and Interglacial, page 1). Students engage in an activity to simulate how bear populations may have moved as a result of glacial periods and engage in a discussion of the following questions: “What options do bears have in each location when the amount of ice changes? How would bears living in Greenland experience the changes differently from bears living in Wapusk/Canada/Europe? What selection pressures existed during that time in that location? How quickly did the climate change?” (Teacher Edition, page 91).
- Lesson 5: The following idea is indicated as something to look/listen for in the class consensus model: “Brown bear populations will expand because climate change melts the ice earlier than

before, increasing their available range and making more food available to them" (Teacher Edition, page 111).

- Lesson 7: Students make an argument relating mass extinctions and changes in Earth's temperature and ocean chemistry. "What to look for/listen for in the moment: arguments supported by evidence (SEP 7.4) that include: Mass extinctions were caused by patterns of significant biological and geological events that caused drastic swings in Earth's temperatures and changes to ocean chemistry. (DCI LS.4.D.1 + ESS2.E; CCC 1.1) Most of the significant biological and geological events had evidence of major increases or decreases in atmospheric carbon dioxide levels, which caused drastic swings in Earth's temperatures and ocean chemistry. (SEP: 7.4; DCI: ESS2.E.1, LS.4.D.1; CCC: 1.1) Requests for evidence related to the effect of extinctions of biodiversity" (Teacher Edition, page 132).

Thera are some connections made between science domains using CCCs. However, these are not always directly tied to grade-appropriate elements and the connections are not always explicit to students.

- Lesson 1: The CCC elements are addressed later in the unit with further discussion about the significance of scale: "Discuss the significance of scale. Discuss the remaining prompts on slide K. Listen for students to mention that the maps are different in winter and summer and that the bears are not always in the same location. Say, It seems to be important for us to discuss not only where the bears are but also when. We need to pay attention to both space and time. The crosscutting concept scale, proportion, and quantity can help us think about this. Encourage examples from multiple science domains and questions for further investigation. Use the prompts below as a guide" (Teacher Edition, page 27). The provided prompts include: "How is scale important to understanding what is happening with these bears?" and "Can you think of any other times it was important to pay attention to both space and time to understand a phenomenon?" (Teacher Edition, pages 27–28). While a connection is made using patterns, it is tied to elementary-level use of the CCC category rather than to a grade-appropriate element.
- Lesson 1: The use of the "Scale Organizer" handout provides a scaffold for students thinking around the CCC element: *The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs*, by providing timelines in which to record their observations. Students use this organizer to connect Earth science and life science events. After students record information, the following teacher prompt is provided to help guide the class discussion: "How does changing the scale of the data change the trend we notice?" (Teacher Edition, page 31). The following follow-up questions are provided: "What time scale is important? (Are we concerned about seasonal change, human caused climate change, or geologic cycles?)", "Are we concerned about individual bears, populations, or whole species? (Are we interested in genetics, behaviors, evolution, or speciation?)", and "What spatial scale is important? (Are we concerned about resource availability and adaptations in one habitat, an ecoregion, or all of the Arctic?)" (Teacher Edition, page 108). However, this planner is only referenced a few times in the unit and is not revisited frequently. Teacher guidance as to how the tracker should be used by students is not provided.
- Lesson 7: Students look at mass extinction data to find patterns to help them determine causality. The following prompt is found on the provided handout: "1. What patterns did you notice in the evidence across the extinctions in terms of causes and effects?" (B.5 Lesson 7 Handout, Extinctions Graphic Organizer, page 1). While a connection is made using patterns, it is tied to elementary-level use of the CCC category rather than to a grade-appropriate element.

Suggestions for Improvement
Consider adjusting prompts to ensure that connections made across science domains related to CCCs are made using grade-appropriate elements.

I.F. MATH AND ELA

Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects.

Rating for Criterion I.F. Math and ELA	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found Extensive evidence that the materials provide grade-appropriate connections to the Common Core State Standards (CCSS) in mathematics, English language arts (ELA), history, social studies, or technical standards because students are provided with numerous opportunities to use reading, writing, speaking, and listening to fully explain the polar bear phenomenon. Appropriate connections to CCSS in ELA and mathematics are made when appropriate.

Connections to CCSS for mathematics are made where appropriate. Related evidence includes:

- *MP.2 Reason abstractly and quantitatively.*
  - Lesson 1: Students interpret graphs on temperature and the extent of sea ice over time to make predictions about how these changes may affect polar bear populations. They use timelines and maps to build a picture of how different components in the ecosystem interact spatially and over time (Teacher Edition, page 52).
- *MP.4 Model with mathematics.*
  - Lesson 3: "Students calculate percent difference in DNA sequences and use the results to create a tree model to describe relatedness. They use a computer model that uses a similar process to analyze and model larger sequences" (Teacher Edition, page 80).
- Guidance is provided for what mathematics concepts students will engage with in the unit. "This unit requires students to develop mathematical models, use mathematical representations, develop algorithms and use rates of change. Making mathematical models is a Standard for Mathematical Practice, and specific modeling standards appear throughout the high school standards. This unit does not assume students are fluent with the mathematical practices listed below, but that students develop these practices as part of the sense-making. Thus[sic] these standards are not so much prerequisites, as co-requisites. If students are simultaneously developing the skills and vocabulary in math class, you can help by making explicit connections to the mathematical standards below. Talk with the math teacher(s) to identify the strategies students are familiar with for developing algorithms with words or numbers, calculating rates of change, and constructing graphical representations of data" (Teacher Edition, page 14).

Connections to CCSS Standards for ELA are made where appropriate. Related evidence includes:

- **WHST.9-10.7** *Conduct short ~~as well as more sustained~~ research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when*

appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
    - Lesson 8: "Students conduct a short research project using multiple sources to learn about how people protected a particular species or group of species from extinction" (Teacher Edition, page 151).
- **WHST9.12.1** *Write arguments focused on discipline-specific content.*
    - Lesson 4: "Students develop arguments based on evidence from informational texts adapted from scientific literature" (Teacher Edition, page 102).
    - Lesson 7: "Students develop a scientific argument to explain the main cause of mass extinctions" (Teacher Edition, page 138).
- **WHST.9-12.9** *Draw evidence from informational texts to support analysis, reflection, and research.*
    - Lesson 1: "Students read evidence from multiple texts and data sources to analyze the resilience of polar bear populations and predict the future stability of those populations" (Teacher Edition, page 52).
    - Lesson 2: "Students read different polar bear studies and draw information from each case study to explain the fluctuations in their body temperature" (Teacher Edition, page 67).
    - Lesson 3: "Students use evidence from textual evidence in Bear Cards to support their analysis of relationships between bear species" (Teacher Edition, page 80).
    - Lesson 4: "Students develop arguments based on evidence from informational texts adapted from scientific literature" (Teacher Edition, page 102.)
    - Lesson 6: "Students use a graph and information text as evidence about the future of polar bears" (Teacher Edition, page 122).
- **CCSS.ELA-LITERACY.SL.9-10.4** *Present information, findings, and supporting evidence clearly, concisely, and logically so that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.*
    - Lesson 8: "Students create a poster about a case study where people worked to protect a species or groups of species from extinction and present it to their peers in a short amount of time" (Teacher Edition, page 151).

Students are provided with numerous opportunities to engage in reading, writing, speaking, and listening. Related evidence includes:

- Lesson 1: "Investigate bear sightings in Wapusk. Display slide H and pass out Bear Sightings to each student. Explain that they have maps (slides I and J) that show where there have been recent reported sightings of the brown, black, and polar bears in both winter and summer. Ask them to turn and talk with a partner about how they think the bears might interact with the three habitats in Wapusk seasonally. After 3-4 minutes, display slide K and ask a few students to share their ideas" (Teacher Edition, page 27).
- Lesson 1: Students participate in a fishbowl discussion. "Facilitate a fishbowl discussion. Display slide CC. Set up two concentric circles of desks. One representative from each group will sit in the inner circle. One-two student volunteers should also join the inner circle representing Traditional Knowledge. Provide them with access to the quotes from Inuvialuit Quotes. The remainder of desks should create an outer circle where the majority of students will sit. Use the slide prompts to explain how a fishbowl discussion occurs. Refer to the Community Agreements and remind students that the purpose of this discussion is to move their science thinking forward. The goal is to answer the question: How are polar bear populations in different ecoregions affected by changes to Arctic sea[sic] ice? Students in the inner circle will share

information from their ecoregion visual inquiry and discuss the questions on slide DD. Students in the outer circle will listen and complete part 2 of Comparing Polar Bear Populations. Students in the outer circle are responsible for deciding if the class has sufficiently answered the discussion questions. As the chosen representatives, only students in the fishbowl may contribute to the conversation" (Teacher Edition, page 37).

- Lesson 1: Teachers read about the diet, behavior, and reproduction of the three bears.
- Lesson 2: Students are provided with a thermoregulation reading to support them in making sense of their data and connecting it to polar bears.
- Lesson 4: "Display slide W and distribute Bear Fossils Map to each student. Ask students to turn and talk about the data with an elbow partner using the prompt on the slide. Encourage them to compare the dates to Glacial and Interglacial Periods. After 5-7 minutes working in pairs, facilitate a class discussion of what students noticed" (Teacher Edition, page 97).
- Lesson 4: "Students engage in a reading about glacial and interglacial periods. While reading, students are asked to consider the following questions: "What were the major environmental changes over the last 700,000 years? How might these cause selection pressures for bears? What do you wonder about this information?" (B.5 Lesson 4 Handout, Glacial and Interglacial, page 1).
- Lesson 4: Students construct an argument in writing to answer the question: "How did polar and brown bears become different species?" (B.5 Lesson 4 Slides, Slide P)
- Lesson 6: Students engage in reading "Mating Between Bear Species".
- Lesson 7: After viewing information about mass extinction events students are asked to write an initial argument individually with support from others in their small group.
- Lesson 8: Students read one of three case studies about species that are at risk of extinction and fill out a provided graphic organizer.
- Lesson 8: "Share research findings. Display slide L. Direct students to sit with their groups from the last class and share what they figured out from their research. Refer to the community agreements and remind them it is important to hear from all group members to move their science thinking forward" (Teacher Edition, page 147).
- Lesson 8: At the end of the lesson, students individually complete an Exit Ticket using the following prompt: "Complete the Extinction Prevention Argument explaining: Do you think people should make an effort to protect the polar bear from extinction? Choose at least 2 of the solutions from the extinction prevention case studies that you think would be most useful in preventing the extinction of the polar bear. ● Defend an argument for why we should or should not implement those solutions based on the science, constraints and/or ethical considerations" (B.5 Lesson 8 Slides, Slide U).

Suggestions for Improvement

N/A

OVERALL CATEGORY I SCORE: **2** (0, 1, 2, 3)	
Unit Scoring Guide – Category I	
Criteria A-F	
3	At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C
2	At least some evidence for all unit criteria in Category I (A–F); adequate evidence for criteria A–C
1	Adequate evidence for some criteria in Category I, but inadequate/no evidence for at least one criterion A–C
0	Inadequate (or no) evidence to meet any criteria in Category I (A–F)

CATEGORY II

NGSS INSTRUCTIONAL SUPPORTS

II.A. RELEVANCE AND AUTHENTICITY

II.B. STUDENT IDEAS

II.C. BUILDING PROGRESSIONS

II.D. SCIENTIFIC ACCURACY

II.E. DIFFERENTIATED INSTRUCTION

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

II.A. RELEVANCE AND AUTHENTICITY

Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world.

i. Students experience phenomena or design problems as directly as possible (firsthand or through media representations).

ii. Includes suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate.

iii. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience.

Rating for Criterion II.A. Relevance and Authenticity	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found Adequate evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world because the polar bear phenomenon is presented as something authentic that students would want to figure out. While students are provided with a little support to connect their learning to their own experiences, these opportunities mostly occur early in the unit. Additionally, guidance is not provided for teachers to cultivate questions that relate to students' own lives or communities.

The polar bear phenomenon is presented as an authentic scenario that is important to figure out. Students are provided with the opportunity to experience the phenomenon as directly as possible. Related evidence includes:

- Lesson 1: Students are introduced to the phenomenon of the three different types of bears meeting in the same area using pictures and videos. Students are asked to fill out a "Notice and Wonder" chart to document their observations and questions. Guidance is provided to teachers for the types of questions which should be listened for. "Introduce the final unit of the year. Celebrate your classroom community's progress throughout the year using science and engineering practices, crosscutting concepts, and science ideas to figure out and explain biological phenomena. Display slide A. Introduce students to the phenomenon described on the slide. Photographs from one trail camera in Wapusk National Park captured images of a polar bear, brown bear, and black bear in the same location for the first time ever. Display slide B and ask students to set up a Notice and Wonder chart before showing https://youtu.be/PJoraSrB-QQ. Display slide C and ask a few students to share their noticings and wonderings" (Teacher Edition, page 25). A map is used to orient students to Wapuski (the location at which the three bears were sighted together).
- Lesson 1: Students are provided with quotes from the Inuvialuit community about the Arctic habitats and animals. "Share Inuvialuit quotes about polar bears. Explain that you could not find direct information from people who live in Wapusk, but you found a research project that gathered local knowledge about how changes in climate impact polar bear populations from another region of Canada. Display slide V. Say, The Inuvialuit (In-oo-vee-A-loo-weet), are a group of people who have lived in part of what we now call the Arctic regions of Canada for

generations. Many hunt animals on the Arctic sea[sic] ice for food and clothing, so they have first hand[sic], generational knowledge of the Arctic habitats, the seasonal changes, as well as the behavior of many of the animals. Traditional Knowledge of the sea ice and the Arctic is passed on from generation to generation in the Inuvialuit community. The Canadian government collaborated with Traditional Knowledge holders to learn more about polar bear populations in the region" (Teacher Edition, page 34). The connection to the Inuvialuit perspective may help students feel compelled to figure out the phenomenon due to its cultural significance. However, students are not supported to then connect the phenomenon to their own lives and communities.

- Lesson 6: The hybrid bear is introduced by using a quote from the Inuvialuit community. "Introduce new data from the Inuvialuit community. Say, I know some of you are concerned about polar bears and extinction and others wonder if the polar bears and brown bears might interact and mate. I found some very interesting data about instances where polar and brown bears have interacted in the wild. Display slide F and explain to students that the first piece of data comes from members of the Inuvialuit (In-oo-vee-Aloo-weet) that we heard from in Lesson 1. Read the quote to students. Then, ask students to turn and talk to a partner to interpret the quote. Call on a few pairs to share their ideas about what the quote tells them such as: People have seen polar and brown bears mating before. They have also seen half breeds, half polar half brown bears and can recognize them" (Teacher Edition, page 119). Students are also provided a study by professional scientists. "Introduce a study of polar and brown bears that mated and produced offspring. Let students know that you have some additional data from a study published by scientists that you have summarized. Display slide G. Distribute Mating Between Bear Species to each student. Ask students to read on their own using whatever literacy strategy is in place in your classroom" (Teacher Edition, page 119).

Support is provided to teachers to support issues which may arise when addressing what might happen to polar bears as the climate changes. Related evidence includes:

- "How do I support students' emotional needs? In this unit, students explore the challenges associated with climate change and extinction of species. These raise issues concerning climate anxiety, decision making, and animal welfare. Students may have emotional needs related to two main issues: Anxiety about the effects of climate change; Strong beliefs about animal well-being. Before beginning this unit, make sure to reach out to the counselor at your school for student-specific support and strategies that might be needed in regards to the students in your classroom" (Teacher Edition, page 17). Guidance is then provided for how students could be supported.
- Lesson 1: The following teacher guidance is provided in the "Attending to Equity" section in the margins to attend to social and emotional learning. "Social and Emotional Learning: Research on climate change anxiety suggests some young people can have lasting mental health consequences from climate change anxiety. For example, see https://www.thelancet.co m/journals/lanplh/article/PIIS2542-5196(20) 30223-0/fulltext. Symptoms associated with climate anxiety include panic attacks, insomnia, and obsessive thinking. If you suspect any of your students are experiencing anxiety, refer them to appropriate student mental health services" (Teacher Edition, page 29).
- Lesson 1: "Pause for a SEL moment. Display slide O. Say, We are spending time in this unit looking at the impacts of climate change. These effects are complex and involve human and nonhuman parts of the Earth's systems. We need to respect everyone's lived experiences and thoughts about these issues. As we do this, you may have a variety of feelings that you experience. Here is a tool to help you name or identify those feelings. Hand out the Feelings

Wheel at this time as a reference for students to use to identify their feelings throughout the unit. Remind students that all feelings are valid" (Teacher Edition, page 31).

- Lesson 1: "Check in with how students are feeling. Display slide MM. Say, As I mentioned earlier, learning about the impacts of climate change on bear populations may bring up feelings for you. I want to give everyone a chance to do a social and emotional check-in about the predictions we are making with this model. Encourage students to take time to turn and talk with a trusted peer, write independently in their science notebooks, or think about how they feel about what is happening with the Arctic bears. They can use the feelings wheel from Feelings Wheel to help them identify or name an emotion. Encourage them to talk to you or another trusted adult if you notice they have feelings they want to share about what they read" (Teacher Edition, page 44).
- Lesson 8: "Facilitate a social and emotional learning reflection. Display slide K. Provide time for students to reflect on their feelings about their case study using the feelings wheel from lesson 1. They may choose between talking to a trusted peer, silent reflection in their science notebook, or thinking about how they feel about the extinction data. Encourage students to use the feelings wheel to help articulate their feelings or give them the language they need to process them. If they need further support, suggest they share with a trusted adult" (Teacher Edition, pager 146).
- Lesson 9: "Facilitate a social and emotional learning reflection. Display slide J. Provide time for students to reflect on their feelings about extinction using the feelings wheel from Feelings Wheel. They may choose between talking to a trusted peer, silent reflection in their science notebook, or thinking about how they feel about the extinction data. Encourage students to use the feelings wheel to help articulate their feelings or give them the language they need to process them. If they need further support, suggest they share with a trusted adult" (Teacher Edition, page 129).

Students are provided with some opportunities throughout the unit to connect the phenomenon to their own lives and communities. However there are few of these opportunities and most occur early in the unit. Related evidence includes:

- The Progress Tracker used throughout the unit has the following prompt: "How does WWFO connect to me or my community, or have a larger-scale impact?" (Teacher Edition, page 66). However, teacher guidance is not provided for how to use the information students record for this question and student responses to this part of the tracker are not utilized or discussed in the unit.
- Lesson 1: Students are provided with an opportunity to connect their data exploration to their own lives through a home learning opportunity. "Introduce home learning. Say, The data exploration helped us better understand some of the impacts of climate change on the ice and tundra in the Arctic. Who could we talk to in our community to learn more about how changes in environmental conditions have affected our community? Many times data like temperature trends do not tell us what is actually happening in a particular place. People who live there notice changes to plants and animals and other particular events that do not show up on a graph. Display slide P and ask students to follow the prompts tonight, taking notes in their science notebook about what they learn to bring back for discussion in the next class" (Teacher Edition, page 32). Additional guidance as to how these experiences could connect to learning in later lessons is not provided.
- Lesson 2: Guidance is provided for students to share their prior knowledge about overheating and connect it to their own experiences. "Initial Ideas Discussion About Overheating. Display slide J and ask students to turn and talk to a partner about what happens when an animal overheats using their own personal experiences. Use the prompts below as a guide" (Teacher

Edition, page 61). Some of the prompts provided include: "How do you keep yourself cool so you do not pass out?" and "What happens when you or other animals overheat?" (Teacher Edition, page 61).
- Lesson 4: "apoB is associated with the production of low-density lipoproteins, or LDL. LDL cholesterol is a known risk factor for heart disease in humans. Scientists do not understand the exact mechanism of the gene variant in polar bears, but they do recognize its role in helping them cope with high levels of fat in their diet and extremely elevated levels of cholesterol in their blood due to the consumption of seals as their main energy source. Some students may have personal connections to individuals with high cholesterol and heart disease. This may make the fatty diet of polar bears more relevant to them" (Teacher Edition, page 100). While an opportunity for a connection is present, additional guidance is needed in order to assist students in fostering how this increases relevance for students. In addition, there is a missed opportunity to provide teacher guidance to support students who may have family members who have been affected by issues related to high cholesterol.
- Lesson 8: "If there is another case study you believe would generate higher interest for your students, exchange it for an existing case study. If you make a change, make sure you include the following ideas: An introduction to the species A brief overview of the threat Data on the current and historical population size (including status as threatened/endangered/etc.) Information about genetic diversity within the species. Overview of interest holders involved in protecting/opposing species protection. Ongoing concerns and a teaser for further research. References that suggest organizations, individuals or resources to investigate" (Teacher Edition, page 145). While this presents an opportunity for students to connect learning to their own interests, teacher guidance is not provided to elicit ideas related to the types of case studies students may find of higher interest.

Students are provided with opportunities to ask questions related to the phenomenon. However, these opportunities are not tied to students' experiences or culture and teacher support is not provided to cultivate these types of questions. Related evidence includes:
- Lesson 1: Students are prompted to ask questions following viewing of the different types of data throughout the unit and also after thinking about the classroom consensus model. Students then brainstorm additional questions after looking at the initial phenomenon and all data sets and use the questions to create a DQB. Teacher guidance is provided to guide students in brainstorming questions about the past and future polar bear populations. However, there is a missed opportunity for the teacher to cultivate student questions that come from their experiences, communities, or cultures.
- Lesson 5: Students add additional questions to the DQB. However, there is a missed opportunity for the teacher to cultivate student questions that come from their experiences, communities, or cultures.

Suggestions for Improvement
- Consider providing guidance to teachers to cultivate student questions related to their own experiences, communities, and cultures.
- Consider providing additional opportunities for students to make connections to their own communities and cultures, especially in the second half of the unit, through drawing out the funds of knowledge students bring to the classroom and questions they have from their daily lives.

II.B. STUDENT IDEAS

Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and respond to peer and teacher feedback orally and/or in written form as appropriate.

Rating for Criterion II.B. Student Ideas	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials provide students with opportunities to both share their ideas and thinking and respond to feedback on their ideas. Students' ideas are consistently elicited throughout the unit, and they have numerous opportunities to share their ideas with others in both small group and whole group settings and receive peer feedback.

Students are provided with opportunities to share, justify, and modify their thinking about the phenomenon. Related evidence includes:

- Lesson 1: "Investigate bear sightings in Wapusk. Display slide H and pass out Bear Sightings to each student. Explain that they have maps (slides I and J) that show where there have been recent reported sightings of the brown, black, and polar bears in both winter and summer. Ask them to turn and talk with a partner about how they think the bears might interact with the three habitats in Wapusk seasonally. After 3-4 minutes, display slide K and ask a few students to share their ideas" (Teacher Edition, page 27).
- Lesson 1: Students individually develop initial models. "Develop initial models. Display slide JJ. Form groups of 3-4 and distribute a blank piece of chart paper and colored markers to each group. Have students draw a line through the center and give them 10 minutes to develop two models that explain what will happen to the populations of Arctic bears living in habitats with seasonally available vs. permanent ice as their environment changes. Suggest that groups list components, interactions, and mechanisms they want to include before they begin their models. Encourage the use of pictures, symbols, and/or words in their model to help represent and further explain their ideas. Prompt groups to consider factors related to climate change, habitat change, and interactions with other bears as they develop models. Encourage students to record any questions that emerge for them as they develop their models. They will build a Driving Question Board at the end of the lesson and productive questions will likely arise while modeling. Explain that they will be sharing these models with their peers, so they should make sure ideas are labeled and explained clearly" (Teacher Edition, page 40). Students then post their models around the room and participate in a gallery walk in which they note similarities and differences between models. During the gallery walk, students are instructed to "look for key ideas that could be included in a class consensus model" (Teacher Edition, page 44). Students then engage in discussion based on their modified thinking to create a classroom consensus model.
- Lesson 1: "Generate ideas for investigation. Congratulate students on generating a productive board full of great questions. Let them know that the next step is to brainstorm ideas that will help us figure out how to answer those questions. Display slide SS. They should focus on one question at a time and generate ideas for how they could go about answering each question. Their first instinct may be to 'do research.' Prompt them to be more specific and answer questions about what specific data they would need to answer each question. Consider modeling an example to get them started. Give students two minutes to generate ideas for

investigation in their science notebooks. Ask students to share their ideas and record them on a list on a whiteboard or chart paper titled 'Ideas for Investigation'" (Teacher Edition, page 48).

- Lesson 2: Guidance is provided for students to share their prior knowledge about overheating and connect it to their own experiences. "Initial Ideas Discussion About Overheating. Display slide J and ask students to turn and talk to a partner about what happens when an animal overheats using their own personal experiences. Use the prompts below as a guide" (Teacher Edition, page 61). Some of the prompts provided include: "How do you keep yourself cool so you do not pass out?" and "What happens when you or other animals overheat?" (Teacher Edition, page 61).
- Lesson 2: "Make claims about possible bear interactions. Display slide B. Say, We know that brown, black and polar bears are more likely to interact as the Arctic warms, especially in areas with seasonally available ice. Distribute Bear Interaction Claims. Ask students to work with a partner and construct a claim ✱ about how and why they think the different combinations of bear species will interact" (Teacher Edition, page 58). Students then work in small groups to adjust their thinking. Lesson 2: "Add additional evidence, revise claims and explain reasoning in small groups. Say, Do we have enough evidence to support our claims and provide reasoning? Listen for students to say that we need more information. Display slide H and organize students into small groups of 3-5. Let them know you have a set of cards that has some of the information about each of the bear species that they read about organized graphically. Distribute a copy of the Bear Cards https://docs.google.com/presentation/d/1n9BkSKc3xRpCAr4VkpEXco43sw8s90GrnmvJNt7P46I/edit#slide=id.g1ec8fbc6752_0_0 to each group and ask them to discuss the data and fill in additional evidence that supports or refutes each claim in Bear Interaction Claims. Then, ask them to revise their claims and explain their reasoning" (Teacher Edition, page 59).
- Lesson 4: "Facilitate a building understandings discussion. Arrange the class in a Scientists Circle and display slide Q. Ask a few students to share their claims and discuss how they are similar or different from their partner's. Write at least one student claim on the board to use during the discussion to demonstrate how to support and turn it into an argument during the discussion. Discuss the prompt on the slide. Listen for students to mention they need evidence and reasoning to support their claims to turn them into arguments. If necessary, ask what they need to prove or convince someone that their claim makes sense" (Teacher Edition, page 92).
- Lesson 7: "Activate student knowledge about extinctions. Ask students if they know of any species that have gone extinct. Listen for students to mention dinosaurs, mammoths and other species. After students share what they know, display slide F which shows some of animals that have gone extinct" (Teacher Edition, page 128).

Students are provided with frequent opportunities to share how their thinking has changed and receive feedback. Related evidence includes:

- Lesson 1: "Prepare for a gallery walk. Post the group models around the room where all students can see them. Display slide MM. Let students know that they will interact with some of their peers' models through a gallery walk. Ask them to prepare a T-chart in their science notebooks to record similarities and differences between models. They should look for key ideas that could be included in a class consensus model" (Teacher Edition, page 44).
- Lesson 2: "Make claims about possible bear interactions. Display slide B. Say, We know that brown, black and polar bears are more likely to interact as the Arctic warms, especially in areas with seasonally available ice. Distribute Bear Interaction Claims. Ask students to work with a partner and construct a claim about how and why they think the different combinations of bear species will interact" (Teacher Edition, page 58).

- Lesson 2: "Add additional evidence, revise claims and explain reasoning in small groups. Say, Do we have enough evidence to support our claims and provide reasoning? Listen for students to say that we need more information. Display slide H and organize students into small groups of 3-5. Let them know you have a set of cards that has some of the information about each of the bear species that they read about organized graphically. Distribute a copy of the Bear Cards https://docs.google.com/presentation/d/1n9BkSKc3xRpCAr4VkpEXco43sw8s90GrnmvJNt7P46I/edit#slide=id.g1ec8fbc6752_0_0 to each group and ask them to discuss the data and fill in additional evidence that supports or refutes each claim in Bear Interaction Claims. Then, ask them to revise their claims and explain their reasoning" (Teacher Edition, page 59).
- Lesson 4: After gathering information about how the Earth changed during glacial periods, students make a claim to answer the question "How did polar and brown bears become different species?" (B.5 Lesson 4 Slides, Slide P). After having an opportunity to share their claim with another student to look for similarities and differences, the class engages in a discussion. "Facilitate a building understandings discussion. Arrange the class in a Scientists Circle and display slide Q. Ask a few students to share their claims and discuss how they are similar or different from their partner's. Write at least one student claim on the board to use during the discussion to demonstrate how to support and turn it into an argument during the discussion. Discuss the prompt on the slide. Listen for students to mention they need evidence and reasoning to support their claims to turn them into arguments. If necessary, ask what they need to prove or convince someone that their claim makes sense" (Teacher Edition, page 92). Students are asked to create an initial argument using a provided handout which contains a graphic organizer. "Construct an Initial Argument. Display slide R and distribute Developing an Argument to each student. Facilitate a discussion about how to build an initial argument using the graphic organizer on Developing an Argument. Students can add their claim to Part 1 of Developing an Argument. Discuss the evidence students have to support the sample claim written on the board. Demonstrate how to add that information to the evidence column on Developing an Argument. Students may need to refer to other handouts in their science notebook for evidence. Discuss how to add reasoning to the graphic organizer on Developing an Argument for each piece of evidence. Refer to the prompts below or Key Developing an Argument for sample entries using Day 1 evidence" (Teacher Edition, page 93). In addition to the graphic organizer, the following guidance for writing an argument is found on the handout: "Arguments should contain the following (not necessarily in the order shown): 1. Claim: Answer the question including both when, where and why you think this occurred. 2. Evidence: Describe what data you have to support each part of your claim. 3. Reasoning: Use science ideas to describe how the evidence supports your claim. Create a story that links the evidence to your claim using science ideas" (B.5 Lesson 4 Handout, Developing an Argument, page 1). After constructing their initial arguments, students look at fossil data and discuss whether or not the new evidence supports or refutes their argument. Students then revise their arguments. "Update evidence lists. Display slide X. Say, So it sounds like the fossil evidence was useful for supporting some of our arguments for why bears split and maybe gave some of us some ideas of how we might need to revise our arguments. Let's take a few minutes to revise Developing an Argument" (Teacher Edition, page 98). After looking at genetic data, students again update their claim and argument.
- Lesson 7: After viewing information about mass extinction events students are asked to write an initial argument individually with support from others in their small group. "Write initial arguments. Display slide N and provide time for students to individually write their initial arguments on Part C of Extinctions Graphic Organizer. Encourage students to support the people in their group during this process" (Teacher Edition, page 131). After writing their

responses, students are given a chance to reflect on their argument and then receive some peer feedback. A handout is provided to guide peer feedback which includes the following prompts: “Does the claim explain the main cause of mass extinctions on earth?”, “Is the claim easy to understand?”, “Do they provide a pattern of evidence?”, “Does the evidence directly relate to the claim?”, and “Does the reasoning connect the evidence to the claim?” (B.5 Lesson 7 Handout, Peer Feedback Rubric, page 1). Students are provided with an opportunity to revise their initial argument. “Revise initial arguments. Say, I think we now have a better understanding of what caused mass extinctions in the past and the consequences for biodiversity. Let’s spend some time revising our arguments. Display slide W and provide time for students to revise arguments based on the prompt. Point out the subtle change in the argument writing prompt and that they should make sure they are explaining how extinctions affect biodiversity and supporting this idea with additional evidence if necessary” (Teacher Edition, page 135).

- Lesson 8: Students consider arguments for if we should save the polar bear from extinction. After answering the question as individuals, students are instructed to engage in a discussion in small groups. “Evaluate options for the polar bear in groups. Say, We are still forming our arguments for if we should save the polar bear from extinction and we did not have a chance to look at all of the options from the case studies yesterday. Display slide S. Explain that students will return to the same groups they worked with to create their poster. First[sic] they will share with the other half of their group what they figured out from the extinction prevention case studies. Students should be open to listening to what the other half of their group saw yesterday as it may sway the argument they wrote in the opening navigation. Once they finish sharing what they learned from the case studies, they can take turns sharing their arguments and then respectfully discuss if people should intervene to save the polar bear. As groups discuss, as needed prompt students with questions such as: Do the new solutions you heard about change your argument about what should be done? What evidence do you have that this would help/hurt the polar bears? What evidence do you have that this could maintain genetic diversity in the population? What makes this technique challenging to implement? Who would need to be involved to make this successful? Do your ethical concerns fit with the science ideas we have figured out?” (Teacher Edition, page 149). The following additional teacher guidance is found in the **Supporting Students in Engaging In Argument From Evidence** section in the margins: “Throughout the second and third day of this lesson, students evaluate different options for protecting species from extinction in order to develop a logical argument for whether people should intervene to protect polar bears from extinction. Explain that while there is no right answer to this question, students should still challenge one another to use scientific evidence to support their statements. They should also be encouraged to ask about relevant factors that may make it difficult to implement solutions, such as cost, space, time, technological capability, and ethical considerations. Remind students that in previous units such as Fires Unit and Natural Selection Unit they also made these types of decisions based on who was involved in decision-making, and how challenging it is to meet the needs of all interest-holders” (Teacher Edition, page 149). Students then engage in the discussion as a large class. At the end of the lesson, students individually complete an Exit Ticket using the following prompt: “Complete the Extinction Prevention Argument explaining: Do you think people should make an effort to protect the polar bear from extinction? Choose at least 2 of the solutions from the extinction prevention case studies that you think would be most useful in preventing the extinction of the polar bear. Defend an argument for why we should or should not implement those solutions based on the science, constraints and/or ethical considerations” (B.5 Lesson 8 Slides, Slide U).

- Many of these artifacts are completed in groups and the follow up tasks usually involve a group discussion. As a result, it is not clear that all students have sufficient opportunities to show how their own thinking has changed over time.

Suggestions for Improvement

- Consider providing additional opportunities for peer and teacher feedback.
- Consider revising some of the group artifacts to individual artifacts so that teachers can know about the thinking of all students and provide individualized feedback.

II.C. BUILDING PROGRESSIONS

Identifies and builds on students' prior learning in all three dimensions, including providing the following support to teachers:

i. Explicitly identifying prior student learning expected for all three dimensions

ii. Clearly explaining how the prior learning will be built upon.

Rating for Criterion II.C. Building Progressions	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found Adequate evidence that the materials identify and build on students' prior learning in all three dimensions because prior learning is indicated for all three dimensions and the progression of learning is clearly outlined in the unit materials. However, the progression of learning is not consistently provided at the element level for CCCs and SEPs.

Information regarding prior proficiency is provided in the unit introductory materials. Related evidence includes:

- "This unit uses and builds upon disciplinary core ideas (DCIs) and other science ideas that students should have previously developed in OpenSciEd Middle School or another middle school science program" (Teacher Edition, page 13). The materials then list all of the MS and HS DCIs that are expected as prior proficiency for the unit.
- The following information is provided regarding expected prior knowledge of SEPs and CCCs: "This unit uses and builds upon high school level Science and Engineering Practices (SEPs) and Crosscutting Concepts (CCCs) that students should have previously developed in OpenSciEd High School Biology and will continue to build in future units in OpenSciEd High School Chemistry and Physics. The progression of these practices and concepts across the program are as follows…" (Teacher Edition, page 12). An accompanying table outlines which SEPs are focused on in each OpenSciEd unit. However, this information is not provided at the element level.

The "Where We Are Going" and "Where We Are NOT Going sections" of many lessons specify prior learning for many DCIs, SEPs, and CCCs and how this learning is built upon. Related evidence includes:

- Lesson 1: “This unit builds on ideas from previous OpenSciEd Biology units, such as natural selection in OpenSciEd Unit B.4: How is urbanization a driving force of evolution? Should we design urban spaces more hospitably for non-human species? (Evolution 1 Unit); rising temperatures and the effects on Arctic ecosystems in OpenSciEd Unit B.2: What causes fires in ecosystems to burn and how should we manage them? (Fires Unit); and limiting factors, carrying capacity and interactions, and ecosystem resilience from OpenSciEd Unit B.1: How do ecosystems work, and how can understanding them help us protect them? (Serengeti Unit). In Serengeti Unit students built a partial understanding of LS2.C.1: A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. This lesson builds toward a complete understanding of the DCI by focusing on Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. In Serengeti Unit students built a partial understanding of LS2.C.2: Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation…can disrupt an ecosystem and threaten the survival of some species. This lesson builds toward a complete understanding of the DCI by focusing on how climate change can disrupt an ecosystem and threaten the survival of some species. Students developed a partial understanding in Natural Selection Unit that Changes in the physical environment, whether naturally occurring or human-induced, have thus contributed to the expansion of some species. They will continue to develop an understanding in this unit that speciation and extinction…have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. This lesson focuses on how changes to the environment contribute to the possible expansion of the brown bear and decline of the polar bear. Speciation will be discussed beginning in Lesson 3. In this lesson, students use elements of the science practice asking questions and developing and using models, which were developed in previous units of OpenSciEd Biology. They intentionally develop a new element of the practice of obtaining, evaluating, and communicating information as they encounter, evaluate, and discuss different types of information and data from Western science and Traditional Knowledge and consider the usefulness of each type of evidence in answering their questions. Students use elements of the crosscutting concepts of patterns, cause and effect, and scale, proportion, and quantity, which were developed in previous OpenSciEd Biology units. Data at different scales is a focus in this unit” (Teacher Edition, page 25). While clear information is provided for development of DCI elements, the information provided about the development of SEPs and CCCs is limited.
- Lesson 1: “This lesson asks students to apply disciplinary core ideas that they developed in Natural Selection Unit, in which they developed a model of evolution by natural selection. These concepts are key to the sensemaking in the lesson, including: LS4.C.2 Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-3), (HS-LS4-4) LS4.C.3 Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3) Students will be introduced to the phenomena of increasing Arctic temperatures and receding Arctic ice to motivate investigations into the evolutionary history and potential future of polar bear populations. However, the explanations behind these

environmental changes, including mechanisms like the Albedo effect or phase-change dynamics, will not be investigated. These mechanisms are the focus of OpenSciEd Unit C.1: How can we slow the flow of energy on Earth to protect vulnerable coastal communities? (Polar Ice Unit) that focuses on thermodynamics in Earth's systems" (Teacher Edition, page 25). While clear information is provided for development of DCI elements, the information provided about the development of SEPs and CCCs is not provided.

- Lesson 2: "In this lesson students investigate homeostasis in the context of the role it plays in interactions between polar and brown bears. Students build on their middle school understanding of information processing from DCI LS1.D: Each sense receptor responds to different input (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain, resulting in immediate behaviors or memories. The science and engineering practice of engaging in argument with evidence is intentionally developed in this lesson as students use scaffolds on day 1 to support them in construct claims supported by evidence. Students use the crosscutting concept of cause and effect in similar ways as they have in previous OpenSciEd Biology units" (Teacher Edition, page 57). While clear information is provided for development of DCI elements, the information provided about the development of SEPs and CCCs is limited.
- Lesson 4: "The lesson develops ESS2.E.1 on both days as students consider how life on earth coevolved with cycles of glaciation. Days 1 and 2 focus on changes to the physical environment that cause speciation (LS4.C.4), whereas day 3 brings in evidence for genetic changes in species, allowing students refine arguments using all of the steps of evolution by natural selection learned in OpenSciEd Unit B.4: How does urbanization affect nonhuman populations, and how can we minimize harmful effects? (Urbanization Unit) to provide a mechanism to support their argument (LS4.C.1). ESS2.E.1 The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. LS4.C.4. Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. LS4.C.1 Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. LS4.C.4 was partially developed in Lesson 1 when students were introduced to the decline of the polar bear and possibility of extinction. This topic will be revisited in Lesson 5 and 8. ESS2.E.1 will be more fully developed in Lesson 7. In this lesson students continue to develop elements of the science practice of Engaging in Argument from Evidence from Lesson 2 as they construct and revise an argument based on data and evidence to explain the speciation of polar and brown bears. Lesson 2 supported students in their ability to articulate simple claims and support them with evidence and reasoning. This lesson scaffolds the development of a more complex argument with a greater variety of possible responses. They will continue to develop this practice with less support in Lessons 7 and 8. This lesson continues to develop this unit's focus on the crosscutting concept **Scale, Proportion, and Quantity**. Students develop elements of this concept by using indirect evidence to develop an argument explaining the speciation of polar and brown bears, a process that occurred over thousands of years in the past" (Teacher Edition, page 85).
- Lesson 5: "Students continue to use elements of developing and using models intentionally developed in previous other OpenSciEd units, including OpenSciEd Unit B.1: How do ecosystems work, and how can understanding them help us protect them? (Serengeti Unit) and OpenSciEd

Unit B.2: What causes fires in ecosystems to burn and how should we manage them? (Fires Unit)" (Teacher Edition, page 106). The specific element of the **Developing and Using Models** SEP is not indicated, therefore it's not clear to the teacher which element students should be familiar with.

- Lesson 6: "Students use the science practice developing and using models to generate evidence to predict future outcomes. Students have used this element in similar ways in previous OpenSciEd Biology units. Students use the crosscutting concept cause and effect to consider the effect of allele recombination on hybrid offspring. Students have used this element in similar ways in previous OpenSciEd Biology units" (Teacher Edition, page 116). While information about development of CCCs and SEPs are provided, the specific element is not referenced.
- Lesson 7: "In OpenSciEd Unit B.1: How do ecosystems work, and how can understanding them help us protect them? (Serengeti Unit) students discovered that biodiversity is necessary for ecosystem resilience. In this lesson, students connect this knowledge to what they figured out about natural selection and speciation earlier in the unit. They figure out causes of mass extinction with mechanisms for recovery of biodiversity. Students note that biodiversity recovered after previous mass extinctions, but this took millions of years. Students discuss how current rates of extinction also threaten the survival of humans as part of the biosphere, and wonder if we should protect species from extinction to prevent greater losses. Students build on their middle school understanding of how life responds to biodiversity loss from MS-LS4.D: Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. The lesson addresses the high school disciplinary core ideas: LS4.D.1 Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (HS-LS4.D.1) ESS2.E.1 The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (HS-ESS2-7) Students build off their knowledge of speciation built in lesson 4 and again look for patterns in Earth's geologic past for evidence to understand how extinction and speciation are connected to major geologic and biologic events. Students continue to develop the science and engineering practice of engaging in argument with evidence to construct and revise arguments about the relationship between climate change, mass extinction, and biodiversity. In lessons 2 and 4 students received scaffolds to construct arguments by writing claims and directly connecting them with evidence and reasoning. In this lesson, formal scaffolds for writing arguments are removed. However, students have the support of peers to write their initial argument. After a whole-class building understandings discussion, students have an opportunity to revise their arguments individually. Students develop the use of the crosscutting concepts patterns by connecting evidence from all 5 mass extinction events to find the cause for the global drop in biodiversity" (Teacher Edition, page 127). While clear information is provided for development of DCI elements, the information provided about SEPs and CCCs is not provided at the element level.
- Lesson 8: "With consideration for social, economic, and cultural constraints to debate if and how humans should intervene to protect the polar bear and other species at risk of extinction. The DCI elements that students put together in this lesson include: ETS.1B.1 When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) LS4.C.5 Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (HS-LS4-5) ETS.1B.1 was developed in OpenSciEd Unit B.1: How do ecosystems work, and how can understanding them help us protect them? (Serengeti Unit) and OpenSciEd Unit B.4: How does urbanization affect nonhuman populations,

and how can we minimize harmful effects? (Urbanization Unit). LS4.C.5 builds on what was developed in Lesson 6 in regards to the polar bear, and asks students to apply what they learned to evaluate if another species has lost its ability to evolve and is in danger of extinction. Students continue to use elements of engaging in argument from evidence developed in Natural Selection Unit, which were developed in lessons 2, 4, and 7. They also continue to develop the element of obtaining, evaluating, and communicating information which was started in lessons 3 and 6, as well as all previous OpenSciEd units. As students are doing open-ended online research, which was not previously developed, scaffolds are provided for evaluating sources and integrating information from each source using a graphic organizer. These techniques will be used again in future OpenSciEd courses. Students continue to use elements from the focal crosscutting concepts cause and effect, developed in OpenSciEd Unit B.2: What causes fires in ecosystems to burn and how should we manage them? (Fires Unit) and Natural Selection Unit. They also use elements of stability and change, developed in Serengeti Unit and Natural Selection Unit" (Teacher Edition, page 143). While clear information is provided for development of DCI elements, the information provided about SEPs and CCCs is more limited.

Suggestions for Improvement

Consider adding information to the "Where We Are Going" section that includes a discussion of prior knowledge of specific SEP and CCC elements and how the lesson will build on that knowledge in a way that mirrors what is done for DCI elements.

II.D. SCIENTIFIC ACCURACY

Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning.

Rating for Criterion II.D. Scientific Accuracy	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials use scientifically accurate and grade-appropriate scientific information because all science ideas in the unit are scientifically accurate and teacher support is provided for ensuring accuracy.

Teacher guidance is provided throughout the unit to ensure scientific accuracy. Related evidence includes:

- Resources are provided in order to help teachers build an understanding of the anchor phenomenon: "In addition to the science content background information embedded in the lesson resources, below we provide recommended resources that can help build your understanding of phenomena and Performance Expectations bundle for this unit: Sea Ice Ecoregions overview (note students see an edited version of this video that does not give away ideas in lesson 1): https://www.youtube.com/watch?v=iaT2SssKc2Q (we have permission from PBI to use this) Tandon, A and Pidcock, R. (December 7, 2022) Polar bears and climate change: What does the science say? Carbon Brief. https://interactive.carbonbrief.org/polar-bears-climate-change-whatdoes-science-say/ Joint Secretariat. 2014. Inuvialuit and Nanuq: A Polar Bear Traditional Knowledge Study. Inuvialuit Settlement Region: Joint Secretariat. p. xvii" (Teacher Edition, page 16).

- Lesson 1: "In this unit, we use brown bear (Ursus arctos) instead of grizzly bear (Ursus arctos horribilis) as much as possible. Grizzly bears are a subspecies of brown bears; all grizzlies are brown bears, but not all brown bears are grizzlies. Original source materials included in this unit occasionally use grizzly bear, grizzlies, or grizzly to describe bears. Brown bear is the broadest identifying name for this group of bears, which includes grizzlies, Kodiak bears, and others across Europe and Asia. It is not necessary to correct students who call them grizzly bears. In fact, it may help prompt personal connections to mention that some people call them grizzly bears. If necessary, post a reminder on the wall that the terms will be used interchangeably" (Teacher Edition, page 26).
- Lesson 3: "This lesson uses intron (non-coding) sequences from a nuclear gene, transthyretin. Inputting different segments of DNA can produce different trees. Many of the trees students could find through an internet search of a bear DNA tree or phylogeny will be built using more DNA than provided in this lesson and with more complex analytical techniques. While trees using different data will vary, most trees will show similar relationships, including close relationships between polar and brown bears and a close relationship between Asian and American black bears. Most trees will also show giant pandas as the outgroup, or the group least related to the other species. We have the students use the guide tree because it has a similar topology to what would be seen if one had rooted the tree under the phylogenetic tree tab. The numbers displayed on the scale are a quantification of the amount of genetic change from the last branch point (node) to present. This mathematical representation is beyond the scope of the lesson, but students may be interested in understanding more about what the numbers represent. If this is the case, you can ask students to consider how they think the mathematical representation could correspond to time. As an extension, ask students to search for other bear trees and motivate them to figure out why the trees might be different. What type of data was the tree built with? What algorithm was used to build the tree? Students could explore why different types of DNA (coding sequences, non-coding sequences, or mitochondrial DNA) might create different types of trees" (Teacher Edition, page 77).
- Lesson 4: "Although changing sea levels accompany glacial and interglacial periods and may have been part of the speciation story for polar and brown bears, the emphasis here is on areas with and without ice. Also note that although there is strong evidence to support claims for population isolation as a mechanism of speciation for the bears, scientists do not yet have a complete picture of what occurred and continue to debate the timing, location, and mechanism of speciation. Because there is still debate in the research literature, there is no 'right answer' to the question posed in this lesson. Help students to create strong arguments based on the evidence they have and provide reasoning that explains how the evidence supports their claim" (Teacher Edition, page 85).
- Lesson 4: "As students argue that bears may have been isolated on islands that retained their ice during interglacial periods, they may ask about their ability to swim to other locations. Polar bears, in particular, are strong swimmers. In one study conducted over 6 years, researchers tracked the movement of 52 bears. On 50 occasions, they recorded the bears swimming distances greater than 30 miles (50 km). Longer recorded distances included 66 miles (106 km), 122 miles (196 km) and 188 miles (303 km). A few swims took a day and some as long as 9 days. The longest recorded swim was 427 miles (687 km). Lynch, Wayne. (2021). Bears of the north: A year inside their worlds. Johns Hopkins University Press" (Teacher Edition, page 91).

- Lesson 4: "apoB is associated with the production of low-density lipoproteins, or LDL. LDL cholesterol is a known risk factor for heart disease in humans. Scientists do not understand the exact mechanism of the gene variant in polar bears, but they do recognize its role in helping them cope with high levels of fat in their diet and extremely elevated levels of cholesterol in their blood due to the consumption of seals as their main energy source. Some students may have personal connections to individuals with high cholesterol and heart disease. This may make the fatty diet of polar bears more relevant to them. Source: Liu, S., Lorenzen, E. D., Fumagalli, M., Li, B., Harris, K., Xiong, Z., Zhou, L., Korneliussen, T. S., Somel, M., Babbitt, C., Wray, G., Li, J., He, W., Wang, Z., Fu, W., Xiang, X., Morgan, C. C., Doherty, A., O'Connell, M. J., Wang, J. (2014). Population genomics reveal recent speciation and rapid evolutionary adaptation in polar bears. Cell, 157(4)" (Teacher Edition, page 100).
- Lesson 7: "Rates of extinction are the number of species that die out over a certain amount of time. The rates on the graph are measured in extinctions per million species-years (E/MSY). If the E/MSY=1, that means if we had one million species, one species would go extinct every year. If there was one species, it would go extinct in one million years. Emphasize the relative rates in the discussion rather than determining the number of species that have gone extinct. After the Industrial Revolution, ecological degradation, habitat fragmentation, overexploitation, the introduction of non-native species, and pollution multiplied as humans relied more on industry, machines, the burning of fossil fuels, and population explosions, causing cities to swell worldwide and scaled up the mechanisms for climate change. There have been so many permanent changes to the Earth due to human activity that some scientists call this period The Anthropocene or The Age of Man" (Teacher Edition, page 130).
- Lesson 7: "If necessary, clarify the difference in scale of extinction rates shown on slides I and K. Slide I is measured in species and slide K is measured in families. Use slide L, hidden in the deck, to explain the relationship between species and families. Families and species are nested within categories of relatedness often based on common characteristics. For example, students investigated 8 bear species in the bear family (Ursidae) in Lesson 3, but not all had the same genus name. Discuss how it is often difficult to identify a species using only fossil evidence, so measurements of extinction over geologic time are usually less specific. As an example, consider on the graph if almost 20 families/million years went extinct during the Ordivician, that would mean that 20 whole categories of living things would be lost every million years, such as all 8 bear species, all 50 species in the duck and goose family (Anatidae), or over 30,000 species of daisies, sunflowers and dandelions in the Aster family. The graph shows the Ordivician extinction happening over millions of years, so the number of lost species would be significant if nearly 20 families were lost every million years during that extinction event" (Teacher Edition, page 131).

Student reading selections include references to scientific journals. Related evidence includes:

- Lesson 1: "González-Bernardo, E., Russo, L. F., Valderrábano, E., Fernández, Á., & Penteriani, V. (2020). Denning in brown bears. Ecology and Evolution, 10(13), 6844–6862. https://doi.org/10.1002/ece3.6372". (Lesson 1 Reading Bear Denning, page 2)

Suggestions for Improvement

N/A

II.E. DIFFERENTIATED INSTRUCTION

Provides guidance for teachers to support differentiated instruction by including:

i. Supportive ways to access instruction, including appropriate linguistic, visual, and kinesthetic engagement opportunities that are essential for effective science and engineering learning and particularly beneficial for multilingual learners and students with disabilities.

ii. Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations.

iii. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts.

Rating for Criterion II.E. Differentiated Instruction	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials provide guidance for teachers to support differentiated instruction because while there is some differentiation guidance provided, the guidance does not adequately address all student groups. In addition, while extensions opportunities are provided, strategies for implementing these opportunities are not always included.

General guidance is provided outlining how the unit provides support for learners. Related evidence includes:

- "Teachers can also find differentiation guidance in the teacher guides in three particular types of callouts: ● Equity callouts focus on moments in instruction in which certain students may benefit from a particular strategy, for example, supporting language development for emergent multilingual learners, providing extended learning opportunities or readings for students with high interest, or providing specific strategies for students with special learning needs. ● Alternate Activity callouts provide guidance to teachers about going further or streamlining activities and/or completing different learning activities based on student progress. These can be particularly helpful for students with high interest or for students or classrooms that need to modify the unit based on availability of time or access to resources. ● Additional Guidance callouts provide more specific instructions to teachers about how to make a learning activity successful based on their students' needs. The callout boxes provide a variety of instructions to modify the timing, grouping, or resources for a particular activity" (Teacher Handbook, pages 48–49)
- "OpenSciEd units are designed to promote equitable access to high-quality science learning experiences for all students. Each unit includes strategies which are integrated throughout the OpenSciEd routines and are intended to increase relevance and provide access to science learning for all students. OpenSciEd units support these equity goals through several specific strategies such as: 1) integrating Universal Design for Learning (UDL) Principles during the unit design process to reduce potential barriers and increase accessibility for students to engage in learning experiences; 2) developing and supporting classroom agreements that encourage a safe

learning culture; 3) supporting classroom discourse to promote students in developing, sharing, and revising their ideas; and 4) specific strategies for supporting emerging multilingual students in science classrooms. Many of these strategies are highlighted in the teacher guides in sidebar callout boxes with the headings of: *Attending to Equity *Supporting Emerging Multilingual Learners *Supporting Universal Design for Learning *Additional Guidance *Alternate Activity *Key Ideas *Discussion callouts" (Teacher Edition, page 17).

Some strategies are provided to address the needs of students who may struggle with the material and with sense-making of the phenomenon. Related evidence includes:

- Lesson 3: Additional guidance is provided for scaffolding. "Ideas for scaffolding: For question 1, compare species 1 and 2 as a class, then ask students to complete comparisons for species 1 and 3 and 2 and 3 with their partner. For question 1 explain: There are 15 bases. Species 1 and 2 have 2 differences, so divide 2 by 15, then multiple by 100 and get 13%. For question 3, recollect either with pairs or as a class how they built their trees previously: They grouped organisms/species that were most similar. In this case, which species are the most similar? Divide the class into groups and have each group complete one comparison" (Teacher Edition, page 75).
- Lesson 4: "If students are struggling to visualize multiple cycles of glaciation, show this second visualization, which shows ice grow and retreat multiple times over the last 400,000 years: Northern Hemisphere Ice Coverage Over Last 400,000 Years. Missed Video/Url ID (OP.BC.VID.L4.101) in tag Note that this visualization only shows glacial ice on land and does not show any sea ice, which is slightly deceptive" (Teacher Edition, page 90).
- Lesson 4: "Universal Design for Learning: Throughout this lesson students engage in activities through multiple formats to provide additional representations. This can help support them as they process the evidence and piece together information from multiple domains and different time and spatial scales. Providing multiple formats for presenting the information provides more access for the diverse learners in your classroom" (Teacher Edition, pages 88–89).
- Lesson 6: "Students will likely need support with making sense of the figure on slide C. The black line represents the actual observations of the sea ice area each September (representing the minimum amount of ice) since 1980. Each of the other lines are projects using a model of what could happen to ice under different climate scenarios. The blue line represents a model with the lowest level of greenhouse gas emission and the red line represents the highest level of greenhouse gas emission. The shading represents variability in the predictions" (Teacher Edition, page 118).
- Lesson 7: "If students do not recall the word resilience, instruct them to look at the personal glossaries from OpenSciEd Unit B.4: How does urbanization affect nonhuman populations, and how can we minimize harmful effects? (Urbanization Unit)" (Teacher Edition, page 128).
- Lesson 7: "If necessary, clarify the difference in scale of extinction rates shown on slides I and K. Slide I is measured in species and slide K is measured in families. Use slide L, hidden in the deck, to explain the relationship between species and families. Families and species are nested within categories of relatedness often based on common characteristics. For example, students investigated 8 bear species in the bear family (Ursidae) in Lesson 3, but not all had the same genus name. Discuss how it is often difficult to identify a species using only fossil evidence, so measurements of extinction over geologic time are usually less specific" (Teacher Edition, page 131).

There is some specific guidance provided for supporting multilingual leaners and language development. However, the strategies provided are limited and not frequently referenced throughout the materials. Related evidence includes:

- Teacher guidance is provided for how teachers can use the word wall to help build understanding of vocabulary. “This unit refers to two categories of academic language (i.e., vocabulary). Most often in this unit, students will have experiences with and discussions about science ideas before they know the specific vocabulary word that names that idea. After students have developed a deep understanding of a science idea through these experiences, and sometimes because they are looking for a more efficient way to express that idea, they have co-developed that definition and can add the specific term to a personal glossary at the back of their notebooks. These ‘definitions we codevelop’ should be recorded using the students’ own words whenever possible. On the other hand, ‘definitions we encounter’ are ‘given’ to students in the course of a reading, video, or other activity, often with a definition clearly stated in the text. Sometimes, definitions we encounter are helpful just in that lesson and need not be recorded in students’ personal glossaries. However, if a word we encounter will be frequently referred to throughout the unit, it should be added. It is best for students if you create consensus definitions in the moment, using phrases and pictorial representations that the class develops together as they discuss their experiences in the lesson. When they co-create the meaning of the word, students ‘own’ the word—it honors their use of language and connects their specific experiences to the vocabulary of science beyond their classroom. It is especially important for emergent multilingual students to have a reference for this important vocabulary, which includes an accessible definition and visual support. Sometimes defining a word is a challenge. The Teacher Guide provides a suggested definition for each term to support you in helping your class develop a student-friendly definition that is also scientifically accurate. The definitions we co-construct and encounter in this unit are listed in this document and in each lesson to help prepare and to avoid introducing a word before students have earned it. They are not intended as a vocabulary list for students to study before a lesson, as that would undermine the authentic and lasting connection students can make with these words when they are allowed to experience them first as ideas they’re trying to figure out” (Teacher Edition, page 17).
- Lesson 5: “Providing a minute for quiet thought before revising the class consensus model provides additional time for all students to process the consensus Gotta-Have-It Checklist and consider how to apply new ideas for the model. This should allow more students to formulate ideas to contribute to the full class discussion. The extra processing time is particularly important for multilingual learners” (Teacher Edition, page 110).
- While both of these strategies are useful for multilingual learners, they are the only instances in which strategies for multilingual learners or language development are addressed.

Opportunities for extensions are provided in the materials, although specific guidance for how these extensions could be implemented is often not provided and the suggestions do not include recommendations for how students can deepen or build toward higher levels within the three dimensions. Related evidence includes:

- In the introductory materials, guidance is provided for extending the unit. “To extend or enhance the unit, consider the following: Lesson 3: Ask students to search for other bear trees and motivate them to figure out why the trees might be different. What type of data was the tree built with? What algorithm was used to build the tree? Students could explore why different types of DNA (coding sequences, non-coding sequences, or mitochondrial DNA) might create different types of trees. Lesson 7: This lesson only briefly touches on the causes and effects of the 5 mass extinction events in Earth's histories. Students who show high interest, may be encouraged to investigate the causes and effects of these events in more detail" (Teacher Edition, page 14).

- Lesson 2: The following suggestion for extension is found in the Where We Are NOT Going section of the lesson: "In the context of homeostasis, this lesson focuses on temperature regulation and does not investigate other metabolic activities that contribute to homeostasis. As an extension, students could investigate the mechanisms behind other aspects of homeostasis" (Teacher Edition, page 57).
- Lesson 7: "This lesson only briefly touches on the causes and effects of the 5 mass extinction events in Earth's histories. Students who show high interest, may be encouraged to investigate the causes and effects of these events in more detail" (Teacher Edition, page 127).
- Lesson 8: "There is insufficient time to fully investigate the status of the species in each case study. The purpose of the investigations is to learn about different techniques used to protect species from extinction, become aware of the significant costs in time and energy that are made to implement these techniques, and evaluate differing perspectives on what, if anything, should be done. If time and interest allows[sic], students could spend more time researching each case study to better inform the final discussions on Day 3" (Teacher Edition, page 143).

Very little specific guidance is provided for differentiation strategies for students who read below grade level. This guidance is primarily found early in the unit. Explicit support for struggling readers is missing in the later parts of the unit. Related evidence includes:

- Lesson 1: "Bear Diet, Bear Denning and Hibernation, and Bear Reproduction are written at similar reading levels. You may wish to allow students to self-select readings based on interest before dividing them into groups. Or, at your discretion, count students into random groups 1-8, or assign them into intentional, mixed-ability reading groups, with the students who need more reading support along with students who do not need the extra support. Bear Reproduction is the shortest. Bear Denning and Hibernation contains some statistics and percentages and could be a good fit for students who are drawn to math and numeracy" (Teacher Edition, page 34).
- Lesson 1: "The quotes can be selected randomly, but some quotes are longer than others or include more challenging words and could be strategically distributed to provide challenges as appropriate. Students who are not confident reading aloud may benefit from receiving a shorter quote in advance and holding onto it until it is their turn to read. Students who are not verbal could receive their quote in advance and use a device with text to speech capability to take their turn to contribute a quote to the circle" (Teacher Edition, page 37).

Suggestions for Improvement

- Consider providing scaffolds such as sentence starters and reading scaffolds to prompt language development needed for sense-making for multilingual learners.
- Consider providing an authentic alternative experience for students who have a high level of interest or who already meet PEs.

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

Supports teachers in facilitating coherent student learning experiences over time by:

i. Providing strategies for linking student engagement across lessons (e.g. cultivating new student questions at the end of a lesson in a way that leads to future lessons, helping students connect related problems and phenomena across lessons, etc.).

ii. Providing strategies for ensuring student sense-making and/or problem-solving is linked to learning in all three dimensions.

Rating for Criterion II.F. Teacher Support for Unit Coherence	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials support teachers in facilitating coherent student learning experiences over time because the unit materials guide teachers on how students can make connections between the lessons using all three dimensions.

Teacher guidance is provided to link learning across lessons. All three dimensions are used to link student learning. However, most learning is connected using DCIs and the SEP of **Engaging in Argument Using Evidence** and CCCs are used less frequently. Related evidence includes:

- Lesson 1: Guidance is provided for the teacher to motivate looking at data and the use of Scale, Proportion, and Quantity. “Frame a data exploration. Display slide L. Say, Great questions! Some of you mentioned that the permafrost is thawing in the Arctic and that you know the ice is also melting due to climate change” (Teacher Edition, page 28). The following teacher prompts are provided: “What type of data would help us understand the effect of climate change in Wapusk?” and “How would the scale of our investigation shift if we want to understand the impact of climate change?” (Teacher Edition, page 29).
- Lesson 2: “Propose starting a Progress Tracker to keep track of ideas. Display slide Y. Say, We have figured out a lot about polar bear thermoregulation and how that affects bear interaction. Let’s capture what we have figured out in this lesson. Distribute Progress Tracker to each student and have students complete a row for Lesson 2” (Teacher Edition, page 66). While a key is provided showing how the Progress Tracker could be filled out in each lesson, specific teacher guidance is not provided for using the tracker in most lessons.
- Lesson 1: “Students prioritize what question(s) to answer next. Display slide TT. Say, We have a lot of questions that we want to try and find the answers to during our last unit. We also have a great list of ideas for how to investigate those questions. Remind the class of the unit question, What will happen to Arctic bear populations as their environment changes? Ask students to review the DQB and their initial ideas for investigation with the unit question in mind. After a minute, ask students to share what question they think the class should investigate next. As students identify specific questions or groups of questions, keep a record of which questions the class thinks should be answered next. Prompt students to consider what aspects of their models are the most incomplete and increasingly motivated to understand the mechanisms better. They might think about which types of data or information would be more readily available to begin. Push students to justify their choices with reasoning for why answering that

question first would be best. Encourage students to connect their reasoning to the broader unit question. Ask students to complete an exit ticket. Display slide UU. Ask students to tear out a half sheet of loose-leaf paper and, based on the DQB and ideas for investigation everyone just shared, write down their ideas for what the class should investigate next and why conducting that investigation would help the class make progress on the unit question" (Teacher Edition, page 49).

- Lesson 2: Guidance is provided for students to look at more evidence to strengthen their argument. "Add additional evidence, revise claims and explain reasoning in small groups. Say, Do we have enough evidence to support our claims and provide reasoning? Listen for students to say that we need more information. Display slide H and organize students into small groups of 3-5. Let them know you have a set of cards that has some of the information about each of the bear species that they read about organized graphically. Distribute a copy of the Bear Cards https://docs.google.com/presentation/d/1n9BkSKc3xRpCAr4VkpEXco43sw8s90Grn mvJNt7P46I/edit#slide=id.g1ec8fbc6752_0_0 to each group and ask them to discuss the data and fill in additional evidence that supports or refutes each claim in Bear Interaction Claims. Then, ask them to revise their claims and explain their reasoning" (Teacher Edition, page 59).
- Lesson 2: Guidance is provided to motivate continued learning. "Summarize what we have figured out so far. Say, I heard some interesting ideas and some disagreement about the reasons that the polar bear might run away from food when they encounter brown bears even if they are very hungry. You mentioned that they overheat and had some questions about that" (Teacher Edition, page 62).
- Lesson 2: Guidance is provided for motivating students to conduct an investigation. "Introduce a thermoregulation investigation. Say, Those are great ideas. We cannot exactly replicate the polar bear treadmill study in our classroom, but I have some ideas for how we can adapt it. Display slide Q and explain to students that you have some thermometers and that they can exercise in class and collect temperature data that will help answer the class'[sic] questions. Distribute Thermoregulation Investigation to each student" (Teacher Edition, page 64).
- Lesson 3: The lesson begins by having students discuss the following prompts to connect the previous lesson to upcoming learning. "What did we figure out in our last class?" and "What new questions did we have?" (Teacher Edition, page 73). Students' discussion of these prompts leads directly to the new learning. "Orient students to similarities and differences between bear species. Say, Great summary. Yesterday we ended with some new questions about how similar/different the bears are. Before we dive into the questions you have about their genetics, let's revisit some of what we already know to see if we can organize what we know about the bears' similarities and differences" (Teacher Edition, page 73).
- Lesson 4: "Motivate a return to the unit question. Display slide x. Celebrate students' accomplishment of writing and supporting a complex argument. Say, When we started this lesson, we said we needed to learn about the past to figure out the future for Arctic bears. Do we have enough information to do that now? Let's investigate this in the next class" (Teacher Edition, page 103.)
- Lesson 4: Guidance is provided for motivating students to look at Arctic climate data to find additional evidence: "Introduce geologic Arctic climate data. Say, You all wanted to know more about selection pressures and what might have been going on in the bears' environment. I have some data about ways the Arctic environment changed over geologic time that may help us figure this out. Review the map on slide H as a class. Give students a few minutes to consider the questions on the slide, then call on a few students to share their ideas using the prompts below as a guide" (Teacher Edition, page 88).

- Lesson 5: "Navigate to today's work. Direct student attention to the class consensus model. Say, We have figured out a lot since we first created our class consensus model in Lesson 1. Display slide B and discuss progress the class has made so far in answering the unit question, What will happen to Arctic bear populations as their environment changes? Use the following prompts as a guide." (Teacher Edition, page 107). The prompts provided include: "What does our current model explain?" and "What new ideas might we need to add to our model?" (Teacher Edition, page 107).
- Lesson 7: "Motivate investigation into past extinction events. Say, We have seen evidence that extinction rates are higher now than before the Industrial revolution and some of us are worried about what the future holds. We know that extinctions have happened way in the Earth's past with the dinosaurs. Since looking at the past helped us think about the future before, let's take some time to look into Earth's past again to see what happened with extinction rates well before the Industrial Revolution" (Teacher Edition, page 130).
- Lesson 7: The following prompt is discussed as a class in order to motivate the need for more evidence: "What information does your group still need to strengthen your argument?" (B.5 Lesson 7 Slides, Slide O).
- Lesson 7: "We have figured out a lot about patterns of past extinctions and discussed a bit about how this could impact our future. Let's capture what we have figured out in this lesson. Be sure to write down the questions our last discussion raises for you. Provide time for students to update Progress Tracker" (Teacher Edition, page 137).

The "Where We Are Going" section of the teacher materials provides additional guidance as to how the lesson connects from the teacher perspective. Related evidence includes:

- Lesson 4: "The lesson develops ESS2.E.1 on both days as students consider how life on earth coevolved with cycles of glaciation. Days 1 and 2 focus on changes to the physical environment that cause speciation (LS4.C.4), whereas day 3 brings in evidence for genetic changes in species, allowing students refine arguments using all of the steps of evolution by natural selection learned in OpenSciEd Unit B.4: How does urbanization affect nonhuman populations, and how can we minimize harmful effects? (Urbanization Unit) to provide a mechanism to support their argument (LS4.C.1). ESS2.E.1 The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. LS4.C.4. Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. LS4.C.1 Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. LS4.C.4 was partially developed in Lesson 1 when students were introduced to the decline of the polar bear and possibility of extinction. This topic will be revisited in Lesson 5 and 8. ESS2.E.1 will be more fully developed in Lesson 7" (Teacher Edition, page 85).
- Lesson 5: "Students continue to use elements of developing and using models intentionally developed in previous other OpenSciEd units, including OpenSciEd Unit B.1: How do ecosystems work, and how can understanding them help us protect them? (Serengeti Unit) and OpenSciEd Unit B.2: What causes fires in ecosystems to burn and how should we manage them? (Fires Unit)" (Teacher Edition, page 106).

- Lesson 6: "Students use the science practice developing and using models to generate evidence to predict future outcomes. Students have used this element in similar ways in previous OpenSciEd Biology units. Students use the crosscutting concept cause and effect to consider the effect of allele recombination on hybrid offspring. Students have used this element in similar ways in previous OpenSciEd Biology units" (Teacher Edition, page 116).

Suggestions for Improvement

- Consider using prompts, such as the one used in Lesson 1, to elicit thinking about CCC elements when linking lessons.
- Consider providing specific guidance for having students revisit their progress tracker a few more times over the course of the unit, especially between Lessons 3 and 7.

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems.

Rating for Criterion II.G. Scaffolded Differentiation Over Time	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials support teachers in helping students engage in the practices as needed and gradually adjusts supports over time because scaffolding is removed and students develop independence in some of the focus SEP elements in the unit. However, sufficient time and scaffolding is not provided for full development of all focus SEPs.

Some teacher supports are provided to support students in building toward SEPs. However, little specific guidance is given.

- Graphic organizers for developing arguments are utilized in several lessons throughout the unit in which arguments are constructed (such as in Lesson 2, 4, and 7).
- Lesson 1: The following information is provided to teachers in the "Supporting Students In Obtaining, Evaluating, and Communicating Information" section in the margins: "Throughout this lesson, students are asked to compare, evaluate, and integrate information that comes from multiple sources, including NASA, the Inuvialuit, Canadian government, and peer-reviewed science publications. All sources contribute useful information that provides evidence to explain changes in Arctic ice and the status of polar bear populations, but they provide information at different scales and focus on different aspects of the system with varying degrees of completeness. Facilitate discussions that recognize both the usefulness of each source as well as the gaps or limitations. Putting the pieces together from all sources provides some answers but should raise additional questions and requests for more data to learn what is happening to polar bears in the Arctic" (Teacher Edition, page 34).
- Lesson 8: The following additional teacher guidance is found in the "Supporting Students in Engaging In Argument From Evidence" section in the margins: "Throughout the second and third day of this lesson, students evaluate different options for protecting species from extinction in order to develop a logical argument for whether people should intervene to protect polar bears

from extinction. Explain that while there is no right answer to this question, students should still challenge one another to use scientific evidence to support their statements. They should also be encouraged to ask about relevant factors that may make it difficult to implement solutions, such as cost, space, time, technological capability, and ethical considerations. Remind students that in previous units such as Fires Unit and Natural Selection Unit they also made these types of decisions based on who was involved in decision-making, and how challenging it is to meet the needs of all interest-holders" (Teacher Edition, page 149).

Teacher-provided scaffolding is reduced over time for focus SEP elements related to **Engaging in Argument from Evidence**. However, not all claimed focus elements for this SEP are fully developed over multiple lessons. Related evidence includes:

- **Engaging in Argument From Evidence:** *Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.*
- **Engaging in Argument From Evidence:** *Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.*
    - Lesson 2: Students are supported in making a claim about bear interactions. "Make claims about possible bear interactions. Display slide B. Say, We know that brown, black and polar bears are more likely to interact as the Arctic warms, especially in areas with seasonally available ice. Distribute Bear Interaction Claims. Ask students to work with a partner and construct a claim ✱ about how and why they think the different combinations of bear species will interact. Reference the laminated Bear Adaptation poster from Lesson 1 to remind students of what they figured out already about the three species of bears. Encourage them to utilize readings and handouts in their science notebooks from Lesson 1 to support them. Call on a few pairs to share their predictions. At this point, predictions will vary widely" (Teacher Edition, page 58). The handout provided contains a table which scaffolds the making and supporting their claims by providing a table which asks students the following questions: "Make a claim. How and why will these bears interact in the Arctic as their environment changes? Consider where and when these interactions will take place", "Cite SUPPORTING evidence. What evidence supports your claim?", "Cite REFUTING evidence. What evidence does not support your claim?", "Revised Claim with reasoning. How does the evidence help you explain why and how the bears are interacting?", and "Reflect. Explain any evidence that is hard to reason with or does not support your claim" (B.3 Lesson 2 Handout, Bear Interaction Claims, pages 1–2).
    - Lesson 4: After gathering information about how the Earth changed during glacial periods, students make a claim to answer the question "How did polar and brown bears become different species?" (B.5 Lesson 4 Slides, Slide P). This claim is made without the scaffolds provided in lesson 2. Students share their claim with another student to find similarities and differences. After this, a building understanding discussion takes place in which the teacher models how one of the student's claims can be turned into an argument. Students are then provided with a graphic organizer which they use to develop their argument.
    - Lesson 7: Students write an initial argument. A graphic organizer is provided. However, no class modeling is provided. Students receive peer feedback and then revise their argument individually.

- Lesson 8: Students consider arguments for if we should save the polar bear from extinction and if so, what techniques should be used. After answering the question as individuals, students are instructed to engage in a discussion in small groups. At the end of the lesson, students individually complete an Exit Ticket using the following prompt: "Complete the Extinction Prevention Argument explaining: Do you think people should make an effort to protect the polar bear from extinction? Choose at least 2 of the solutions from the extinction prevention case studies that you think would be most useful in preventing the extinction of the polar bear. ● Defend an argument for why we should or should not implement those solutions based on the science, constraints and/or ethical considerations." (B.5 Lesson 8 Slides, Slide U) The following teacher guidance is specifically provided to teachers about how scaffolding is removed for this task. "Students continue to develop the science and engineering practice of engaging in argument with evidence to construct and revise arguments about the relationship between climate change, mass extinction, and biodiversity. In lessons 2 and 4 students received scaffolds to construct arguments by writing claims and directly connecting them with evidence and reasoning. In this lesson, formal scaffolds for writing arguments are removed. However, students have the support of peers to write their initial argument. After a whole-class building understandings discussion, students have an opportunity to revise their arguments individually. Students develop the use of the crosscutting concepts patterns by connecting evidence from all 5 mass extinction events to find the cause for the global drop in biodiversity" (Teacher Edition, page 127).

- **Engaging in Argument From Evidence:** *Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.*
  - While this element is identified as a focus SEP element in the unit, it is not clear how it is fully developed in the unit, as it is only used in the final unit assessment.
- **Engaging in Argument From Evidence:** *Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).*
  - Lesson 8: Students consider arguments for if we should save the polar bear from extinction. After answering the question as individuals, students are instructed to engage in a discussion in small groups. "Evaluate options for the polar bear in groups. Say, We are still forming our arguments for if we should save the polar bear from extinction and we did not have a chance to look at all of the options from the case studies yesterday. Display slide S. Explain that students will return to the same groups they worked with to create their poster. First[sic] they will share with the other half of their group what they figured out from the extinction prevention case studies. Students should be open to listening to what the other half of their group saw yesterday as it may sway the argument they wrote in the opening navigation. Once they finish sharing what they learned from the case studies, they can take turns sharing their arguments and then respectfully discuss if people should intervene to save the polar bear. As groups discuss, as needed prompt students with questions such as: ✱Do the new solutions you heard about change your argument about what should be done? What evidence do you have that this would help/hurt the polar bears? What evidence do you have that this could maintain genetic diversity in the population? What makes this technique challenging to implement? Who would need to be involved to make this successful? Do your ethical concerns fit with the science ideas we have figured out?" (Teacher Edition, page 149). At the end of the lesson, students write an initial

argument which outlines which solution they would use. While scaffolds are removed within this single lesson, there is not sufficient opportunity within the unit for students to fully develop proficiency of this element.

Suggestions for Improvement

Consider providing additional opportunities for students to develop the focus SEP elements related to valuating design solutions and arguments made by others.

OVERALL CATEGORY II SCORE:
3
(0, 1, 2, 3)

Unit Scoring Guide – Category II	
Criteria A-G	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least two criteria
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

CATEGORY III

MONITORING NGSS STUDENT PROGRESS

III.A. MONITORING 3D STUDENT PERFORMANCES

III.B. FORMATIVE

III.C. SCORING GUIDANCE

III.D. UNBIASED TASK/ITEMS

III.E. COHERENT ASSESSMENT SYSTEM

III.F. OPPORTUNITY TO LEARN

III.A. MONITORING 3D STUDENT PERFORMANCES

Elicits direct, observable evidence of three-dimensional learning; students are using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions.

Rating for Criterion III.A. Monitoring 3D Student Performances	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found Adequate evidence that the materials elicit direct, observable evidence of students using practices with DCIs and CCCs to make sense of phenomena or design solutions. Students are provided with numerous three-dimensional tasks that are driven by phenomenon. However, many assessment tasks are completed as a whole class or in small groups and it's not clear if teachers would be able to assess individual student performance. Additionally, in some tasks, the explicit use of the grade-appropriate CCC elements is not always clear. Also, the final transfer tasks assess an SEP element that is not developed in the unit.

Throughout the unit, the materials frequently elicit evidence that requires students to integrate the three dimensions to make sense of a phenomenon. While CCCs are claimed in the assessments, the use of grade-appropriate CCC elements is often not obvious. In addition, the final transfer task primarily addresses an SEP element that is not explicitly developed in the lesson. Finally, most artifacts that are produced are completed in small groups or with partners and may not necessarily show individual students' performances in the targeted elements. Related evidence includes:

- Lesson 1: Students use their initial models to ask questions about the relationships between bears and what may affect their survival. This task is completed in small groups and as a whole class, so evidence of individual learning is not present. Students integrate the following elements:
  - SEP: **Asking Questions and Defining Problems** *Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.*
  - DCI: **LS1.A. Structure and Function** *Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline — and sometimes the extinction — of some species.*
  - CCC: **Cause and Effect** *Changes in systems may have various causes that may not have equal effects.*
- Lesson 2: Students make claims about how and why they think the different combinations of bear species will interact. Student claims are tied to evidence about how bears regulate their body temperature and how it affects their interactions. Students integrate the following elements:
  - SEP: **Engaging in Argument From Evidence** *Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.*
  - DCI: **LS4.C: Adaptation** *Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms*

can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.
- CCC: **Cause and Effect** *Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.* Guidance is not provided to ensure that students' claims relate to smaller scale mechanisms.

- Lesson 3: Students are asked to answer the following question in their notebooks: "What did you figure out about the polar brown and black bears using DNA?" (B.5 Lesson 3 Slides, slide K). The following elements are claimed as part of this assessment:
  - SEP: **Obtaining, Evaluating, and Communicating Information** *Compare, integrate, and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.*
  - DCI: **LS4.A: Evidence of Common Ancestry and Diversity** *Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.*
  - CCC: **Patterns** *Empirical evidence is needed to identify patterns.*
- Lesson 4: Students construct an argument to explain how changes in the environment lead to the split of brown and polar bears. Students integrate the following elements:
  - SEP: **Engaging in Argument From Evidence** *Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.*
  - DCI: **LS4.C: Adaptation** *Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline — and sometimes the extinction — of some species.*
  - DCI: **ESS2.E. Earth's Systems** *The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it.*
  - CCC: **Scale, Proportion, and Quantity** *Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.* While this CCC element is part of a discussion in the lesson, its use in this task is not explicit.
- Lesson 7: Students are asked to write an argument with the following prompt: "Construct an argument using a pattern of evidence that explains the main cause of mass extinctions on earth" (B.5 Lesson 7 Handout, Extinctions Graphic Organizer, page 2). The following elements are claimed as part of this assessment:
  - SEP: **Engaging in Argument From Evidence** *Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.*
  - DCI: **LS1.A. Structure and Function** *Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.*

- CCC: **Patterns** *Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.* While students use patterns as part of their evidence, the connection between patterns observed and their scale is not explicit.

- Lesson 9: Students complete the Bumblebee Transfer Task. The task is driven by a phenomenon (the status of Bumblebee populations). A provided chart provides specific evidence regarding which SEP, CCC, and DCI elements are addressed. However, the primary SEP element used in the assessment (8.1 *Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments*) is not explicitly claimed or developed in any other lesson prior to this assessment.

Suggestions for Improvement

- Consider structuring some additional tasks so that students have an opportunity to produce artifacts on their own and not with a partner or in a small group.
- Consider revising prompts to ensure students' use of CCC elements in their performances is explicit.
- Consider revising the assessment task in Lesson 9 so that it better aligns with an SEP which is developed within the unit.

III.B. FORMATIVE

Embeds formative assessment processes throughout that evaluate student learning to inform instruction.

Rating for Criterion III.B. Formative	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials embed formative assessment processes throughout that evaluate student learning and inform instruction because frequent formative assessment opportunities are provided throughout the materials. However, information provided to the teacher on how to adjust instruction based on student responses is limited. Most formative assessments involve students writing claims and/or arguments, without alternative means for students to demonstrate proficiency. In addition, while guidance for the teacher is provided for how to respond to formative assessment information, the information provided is often related to how to support students in completing the specific task rather than to further adjust instruction to build proficiency.

Numerous formative assessment opportunities are provided throughout the materials. However, most of these assessments ask for students to respond in writing. Related evidence includes:

- Lesson 1: Students individually develop initial models. "Develop initial models. Display slide JJ. Form groups of 3-4 and distribute a blank piece of chart paper and colored markers to each group. Have students draw a line through the center and give them 10 minutes to develop two models that explain what will happen to the populations of Arctic bears living in habitats with seasonally available vs. permanent ice as their environment changes. Suggest that groups list components, interactions, and mechanisms they want to include before they begin their models. Encourage the use of pictures, symbols, and/or words in their model to help represent and further explain their ideas. Prompt groups to consider factors related to climate change, habitat change, and interactions with other bears as they develop models. Encourage students to record any questions that emerge for them as they develop their models. They will build a Driving Question Board at the end of the lesson and productive questions will likely arise while modeling. Explain that they will be sharing these models with their peers, so they should make sure ideas are labeled and explained clearly" (Teacher Edition, page 40). Students then post their models around the room and participate in a gallery walk in which they note similarities and differences between models. Students then engage in discussion to create a classroom consensus model.

- Lesson 2: Students are provided with a handout to make their claims and find supporting and refuting evidence (Teacher Edition, page 65).
- Lesson 3: Students complete an Exit Ticket. An answer key is provided which outlines how specific questions are related to DCI, CCC, and SEP elements. The following questions are found on the exit ticket which asks students to assess their own learning from each dimension. "How did obtaining and evaluating information from multiple sources during the lesson help you make sense of bear relatedness?" and "How did patterns of information at different scales help you make sense of bear relatedness?" (B.5 Lesson 3 Answer Key, L3 Electronic Exit, page 8). Students are also asked to respond to the following prompt with a yes/no answer: "I understand how today's class ties to the bigger picture for what we're studying in this unit" (B.5 Lesson 3 Answer Key, L3 Electronic Exit, page 8).
- Lesson 4: "Develop an initial claim about the split. Say, We have some idea of what selection pressures the common ancestor bears might have experienced in different locations during the cycles of glaciation. Let's take some time to individually come up with a claim about what caused brown and polar bears to split from their common ancestor during this time period. Display slide O and ask students to turn in a claim following the prompts on the slide. Refer to Key Developing an Argument for a sample claim" (Teacher Edition, page 91). Students then are provided with an opportunity to share their claims with another and look for similarities and differences. "Reread claims. Distribute the exit tickets students wrote at the end of the previous class. Display slide P and provide time for students to share and compare the claims they wrote" (Teacher Edition, page 92).
- Lesson 6: Students complete an Electronic Exit Ticket. The following questions are found on the Exit Ticket: "Describe a time in your own life when you experienced a change in environmental conditions where you saw a decline and how it impacted you", "If polar bears go extinct because all the sea ice disappears, how do you predict that will affect the rest of the Arctic ecosystem?", "How did using models during the lesson help you predict the evolution of the polar bear?", and "How did thinking about cause and effect help you explain the lesson question: What will happen to bear species in the Arctic in the future?" (Lesson 6, Bears Exit Ticket).
- Building understanding and consensus discussions are used throughout the materials to provide students an opportunity to show their thinking. While these opportunities are useful for gathering information about whole group learning, guidance for gathering information about individual student learning form these opportunities is not provided.

Each assessment opportunity has a "What to look for/listen for in the moment" section. There is also a section called "What to do" that provides teacher support for students to complete the task. However, the information provided typically only provides teacher information as to how support students in completing that specific task, rather than on how to further adjust instruction so students build proficiency in the three dimensions. Related evidence includes:

- Lesson 2:
  - "What to look for/listen for in the moment: Claims that cite the following evidence: See Bear Data Analysis for sample student responses.
  - What to do: Listen in on small group conversations to make sure students use relevant evidence to support their claims from both the scientific studies and the bear cards. The polar bear-brown bear interaction is the most complex. Prompt students with the following:
    - Which evidence supports and which refutes your claim?
    - At what time of the year is the interaction between polar and brown bears happening?
    - What are the bears doing at this time?
    - What is going on inside the bear that might cause polar bears to overheat?
  - What to look for/listen for in the moment: As students build and interpret the bear trees from DNA using the computer program (SEP 8.2), listen for:
    - Empirical evidence about genetics used to create groups. (SEP 8.2; DCI: LS4.A.1; CCC 1.5)
    - Explanations that the ongoing branching in trees built using DNA represents multiple lines of descent from a common ancestor. (SEP 8.2; DCI: LS4.A.1; CCC 1.5)
    - Evidence from anatomical and behavioral data that led to similar or different conclusions than DNA data. (SEP 8.2; DCI: LS4.A.1)
  - What to do: Ask students the following questions to prompt their thinking:
    - How did we determine the location of Species 1, Species 2, and Species 3 on the earlier tree?
    - Why did we think bears have similar DNA?
    - What do we mean by related? What characteristic of DNA supports that bears are related.
    - What repeated structure/pattern do you see in a tree?" (Teacher Edition, page 59).
    - While these questions will help students better complete the task, they do not indicate how the teacher can adjust further instruction to build proficiency.
- Lesson 4:
  - "What to look for/listen for in the moment: As students participate in the building understanding discussion about the split of polar and brown bears from a common ancestor and fill in Developing an Argument look and listen for an argument that includes: (SEP: 7.4; DCI: ESS2.E.1 & LS4.C.4):
    - Evidence of glacial and interglacial periods creating a changing environment for bear populations. (SEP: 7.4; DCI: ESS2.E.1 & LS4.C.1; CCC: 3.2)
    - Separation of different populations of bears in different climates, one with Arctic ice and one without. (DCI: ESS2.E.1 & LS4.C.4; CCC: 3.2)
    - Isolation of bears on ice where natural selection favored traits with variations adapted to cold climates. (DCI: ESS2.E.1 & LS4.C.4; CCC: 3.2)
    - Natural selection acted over many generations (over glacial and interglacial periods) to cause a new species to form. (DCI: ESS2.E.1 & LS4.C.4; CCC: 3.2)
    - Questions about evidence for which genetic traits caused evolution by natural selection. (SEP: 7.4; DCI: ESS2.E.1 & LS4.C.4)

        - Questions about additional fossil data to provide evidence for where bears were located during glacial and interglacial periods when new species could have evolved. (SEP: 7.4; DCI: ESS2.E.1 & LS4.C.4; CCC: 3.2)
    - What to do: If students struggle to construct individual arguments after the building understanding discussion, collect Developing an Argument at the end of class to provide individual feedback.
        - Ask students to imagine two populations of common ancestor bears are isolated in two locations during glacial and interglacial periods, one in Greenland and one in Canada. Prompt them to think about how environmental conditions would change, how bears could respond to those changes, and what traits might help them to survive those conditions.
        - Ask students to articulate the reasons why they are having trouble supporting a claim with evidence. Have them write down the type of data or evidence they want to see but do not have in Part 3 of Developing an Argument" (Teacher Edition, page 96).
- Lesson 7:
    - "What to look for/listen for in the moment: arguments supported by evidence (SEP 7.4) that include:
        - Mass extinctions were caused by patterns of significant biological and geological events that caused drastic swings in Earth's temperatures and changes to ocean chemistry. (DCI LS.4.D.1+ESS2.E; CCC 1.1)
        - Most of the significant biological and geological events had evidence of major increases or decreases in atmospheric carbon dioxide levels, which caused drastic swings in Earth's temperatures and ocean chemistry. (SEP: 7.4; DCI: ESS2.E.1, LS.4.D.1; CCC: 1.1)
        - Requests for evidence related to the effect of extinctions of biodiversity.
    - What to do: Remind students of the self-assessment they did on Self-Assessment on Constructing an Argument and to reread how they wanted to improve their arguments. Prompt students to review Bear Interaction Claims and Bear DNA Tree to remember how to write arguments supported with evidence and reasoning. Use Key Extinctions Graphic Organizer to support groups as they develop arguments. Collect Extinctions Graphic Organizer at the end of class from students who struggle with writing arguments to provide additional assistance. Ask probing questions such as:
        - What happened to carbon dioxide levels in each mass extinction event?
        - How did rising/falling carbon dioxide levels affect Earth's temperature?
        - How did that change ocean chemistry?
        - How did that change cause extinction? What evidence do you have to show that pattern?" (Teacher Edition, page 132).

    While these questions will help students better complete the task, they do not indicate how the teacher can adjust further instruction to build proficiency.

In some assessment keys, which are provided throughout the unit, guidance is provided for addressing students at various levels. Related evidence includes:

- Lesson 4: Students are asked to write an initial argument using a provided handout. An answer key is provided which contains sample responses. A rubric is also provided which outlines what to look for in foundational pieces, linked understanding, and organized understanding. Each category specifies what to look for in work at that level as well as example responses. In addition, sample feedback/what to do guidance is provided for each level.

- Lesson 9: Students complete the Bumblebee Transfer Task. An answer key is provided containing additional information for teachers including a table which aligns each question to the appropriate SEP, DCI, and CCC, sample student responses and scoring rubrics containing sample responses at three different levels (Foundational, Linked, and Organized) for some questions. The rubric also contains information about what to do and how to provide feedback at each level.

Suggestions for Improvement

- Consider providing additional suggestions on how teachers can change instruction if the class shows misconceptions or incomplete understanding.
- Consider providing teachers with additional guidance for how to individualize or differentiate instruction based on formative assessment data.
- Consider offering additional formative assessments that use speaking, drawing, or other modality questions in addition to written opportunities, to capture information about individual student learning.

III.C. SCORING GUIDANCE

Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students.

Rating for Criterion III.C. Scoring Guidance	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the included aligned rubrics and scoring guidelines that help the teacher interpret student performance for all three dimensions because sample student responses and rubrics are found for key assessments throughout the materials. However, direct guidance is not provided to students to support them in monitoring their own progress toward key learning.

Assessment opportunities are explicitly called out in the materials. Each opportunity is tied to a three-dimensional learning outcome which is explicitly tied to specific elements of each dimension. In each of these instances, guidance is provided for what to look for and what to do. Related evidence includes:

- Lesson 2:
  - "What to look for/listen for in the moment: Claims that cite the following evidence: See Bear Data Analysis for sample student responses.
  - What to do: Listen in on small group conversations to make sure students use relevant evidence to support their claims from both the scientific studies and the bear cards. The polar bear-brown bear interaction is the most complex. Prompt students with the following:

        - Which evidence supports and which refutes your claim?
        - At what time of the year is the interaction between polar and brown bears happening?
        - What are the bears doing at this time?
        - What is going on inside the bear that might cause polar bears to overheat?
    - Building toward 2.A Make and defend claims about effects of internal conditions on bear behavior. (SEP 7.5; DCI LS1.A.4; CCC 2.4)" (Teacher Edition, page 59).
- Lesson 6:
    - "What to look for/listen for in the moment: Claims using evidence from student models to predict fitness of hybrids in changing Arctic such as…
        - Roughly half of the hybrids will be well adapted to changing Arctic conditions. Those that gain alleles for less fat that do not overheat will be able to survive and reproduce as it gets warmer. (SEP: 2.3; DCI: LS4.C.5; CCC: 2.2)
        - Some of the hybrids will be well adapted to changing Arctic conditions but some will not. Those that have darker fur and do not overheat will be able to hunt well and will be able to fight over food to survive and reproduce. (SEP: 2.3; DCI: LS4.C.5; CCC: 2.2)
    - What to do: Direct students back to Hybridization Model and ask how many hybrids would do well and why. Ask which traits seem most important for survival.
    - Building toward 6.A Use a model to generate new evidence to support claims about the survival of polar bears in the changing Arctic. (SEP: 2.3; DCI: LS4.C.5; CCC: 2.2)" (Teacher Edition, page 121).
- Lesson 7:
    - "What to look for/listen for in the moment: arguments supported by evidence (SEP 7.4) that include:
        - Mass extinctions were caused by patterns of significant biological and geological events that caused drastic swings in Earth's temperatures and changes to ocean chemistry. (DCI LS.4.D.1+ESS2.E; CCC 1.1)
        - Most of the significant biological and geological events had evidence of major increases or decreases in atmospheric carbon dioxide levels, which caused drastic swings in Earth's temperatures and ocean chemistry. (SEP: 7.4; DCI: ESS2.E.1, LS.4.D.1; CCC: 1.1)
        - Requests for evidence related to the effect of extinctions of biodiversity.
    - What to do: Remind students of the self-assessment they did on Self-Assessment on Constructing an Argument and to reread how they wanted to improve their arguments. Prompt students to review Bear Interaction Claims and Bear DNA Tree to remember how to write arguments supported with evidence and reasoning. Use Key Extinctions Graphic Organizer to support groups as they develop arguments. Collect Extinctions Graphic Organizer at the end of class from students who struggle with writing arguments to provide additional assistance. Ask probing questions such as:
        - What happened to carbon dioxide levels in each mass extinction event?
        - How did rising/falling carbon dioxide levels affect Earth's temperature?
        - How did that change ocean chemistry?
        - How did that change cause extinction? What evidence do you have to show that pattern?
    - Building toward 7.A Construct an argument using a pattern of evidence that explains the main cause of mass extinctions on earth. (SEP: 7.4; DCI: ESS2.E.1, LS.4.D.1; CCC: 1.1)" (Teacher Edition, page 132).

Keys are provided for many of the assessments found in the materials which contain sample student responses. While most keys provide only a single sample student response, sample responses at multiple levels are provided for key assessments in the unit. Some keys provide additional guidance for responding to students. Related evidence includes:

- A key for the Progress Tracker is provided containing a sample student response.
- Lesson 1: A key is provided for the Comparing Polar Bear Populations Handout. The key contains a single sample student response for each question as well as discussion notes.
- Lesson 2: Students are provided with a handout to make their claims and find supporting and refuting evidence. A key is provided containing a sample student response.
- Lesson 2: A handout is provided for the student thermoregulation investigation containing questions aligned to DCI and SEP elements. For example: "1. How did human body temperature change during exercise?", "4. How does the variation of the NOS3 gene that polar bear have affect how the polar bear behaved: a. on the treadmill? b. when interacting with brown bears around a whale carcass?", and "5. Make a claim supported by evidence to respond to the following: How and why will polar and brown bears interact in the Arctic as their environment changes? Consider evidence from scientific studies and your own investigations?" (B.5 Lesson 2 Handout, Thermoregulation Investigation, pages 1–2). A key is provided.
- Lesson 3: Students complete an Exit Ticket. An answer key is provided which outlines how specific questions are related to DCI, CCC, and SEP elements. A single sample response along with rationales and what to do if students need additional support are provided for each question. For example, "Correct response: Related because of the similar patterns between each of the bee populations compared to the fruit fly for both the graph and the data table. Rationale: There was evidence of relatedness in the gene sets between the bee populations that were more alike to each other than the fruit fly. Additionally, the fact that they almost have the same percentages of base pairs in common with each other and different that the fruit fly shows a pattern of relatedness across the data. What to do: Encourage students to revisit their science notebooks to see how relatedness was defined and the relationship with genes. They should come up with the idea that the more genetic information that two populations have in common, then they must have had a common ancestor and are, therefore, related to each other" (B.5 Lesson 3 Answer Key, L3 Electronic Exit, page 5).
- Lesson 4: A key is provided for the assessment which contains examples of student responses at various levels of proficiency.
- Lesson 9: Students complete the Bumblebee Transfer Task. An answer key is provided which contains examples of student responses at three levels of proficiency.

Major assessments in the unit contain rubrics which outline performance at multiple levels. These rubrics contain look-fors as well as sample responses at each level. Related evidence includes:

- Lesson 4: Students are asked to write an initial argument using a provided handout. An answer key is provided which contains sample responses. Very specific guidance is provided to evaluate students' claims, evidence, and reasoning. Examples of varied student responses are included. "Example: Polar bears and brown bears split from Polar bears and brown bears split from a common ancestor because one population of common ancestor bears got trapped in Greenland during an interglacial period and another population remained in Canada. During a glacial period, a group of ancestor bears lived in a place that became glaciated. They wandered all over the ice looking for food. Some had better inherited traits for catching food on the ice and survived and reproduced. They passed on those adaptive traits to their offspring[sic] so they had them too. Others without adaptive traits died. The ones that stayed on the ice and adapted became polar bears. The bears on ice had alleles for white fur that helped them sneak up on seals so they could eat. They outcompeted bears that did not have that variation" (Teacher Edition, pages 102–203).

- Lesson 9: Students complete the Bumblebee Transfer Task. Teachers have examples of student responses at three levels of proficiency and are supported in evaluating student work. "Example: The pesticide use went up really quickly after 2003 from 0 to 4 lb/sqm. The pesticide that went up the most is also the most fatal to bees. Bees could not develop any defense to the pesticide. Feedback/what to do: Remind students about the bees in the Electronic Exit Ticket in lesson 3 where they saw that some bees had genes for immunity. If genes for immunity exist, what reasoning could support the claim? Allow students to rewrite their response" (Teacher Edition, pages 216–217).

Students are provided with opportunities to reflect on their progress toward learning of SEPs and CCCs. However, students are not provided with guidance to evaluate their learning. Related evidence includes:

- Lesson 3: Students complete an Exit Ticket. The following questions are found on the exit ticket which asks students to assess their own learning from each dimension: "How did obtaining and evaluating information from multiple sources during the lesson help you make sense of bear relatedness?" and "How did patterns of information at different scales help you make sense of bear relatedness?" (B.5 Lesson 3 Answer Key, L3 Electronic Exit, page 8). Students are also asked to respond to the following prompt with a yes/no answer: "I understand how today's class ties to the bigger picture for what we're studying in this unit" (B.5 Lesson 3 Answer Key, L3 Electronic Exit, page 8).
- Lesson 4: Students are provided with an opportunity to reflect on their initial arguments through the following prompts: "Consider how confident your feel in your argument right now and what additional information you need to support it" and "Write down the additional evidence or data you need to complete your argument on Part 3 of Developing an Argument" (B.5 Lesson 4 Slides, Slide U).
- Lesson 4: "Students complete a self-assessment. Display slide GG and distribute Self-Assessment on Constructing an Argument to each student. Provide time for students to complete the self-assessment. Collect Self-Assessment on Constructing an Argument and make note of what students learned from the process and where they struggled. Bring these ideas to lesson 8, when students will be asked to construct and defend arguments again" (Teacher Edition, page 102).
- Lesson 6: Students complete an Electronic Exit Ticket. The following questions are found on the Exit Ticket: "Describe a time in your own life when you experienced a change in environmental conditions where you saw a decline and how it impacted you", "If polar bears go extinct because all the sea ice disappears, how do you predict that will affect the rest of the Arctic ecosystem?", "How did using models during the lesson help you predict the evolution of the polar bear?", and "How did thinking about cause and effect help you explain the lesson question: What will happen to bear species in the Arctic in the future?" (Bears Exit Ticket).

Suggestions for Improvement

- Consider providing a student friendly rubric or tracker that students can use to monitor and interpret their own progress toward learning in all three dimensions.
- Consider providing teachers with additional guidance for how to individualize or differentiate instruction based on assessment data.

III.D. UNBIASED TASK/ITEMS	
Assesses student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.	
Rating for Criterion III.D. Unbiased Task/Items	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials assess student proficiency using accessible and unbiased methods, vocabulary, representations, and examples because the tasks are accessible and are appropriate for high school students. While there is some variety in modalities for assessments, choice in modality is limited and most major assessment tasks rely on writing as the only modality. In addition, there are few alternate modalities used to present tasks to students.

Text and vocabulary are appropriate to high school level students. Related evidence includes:

- "It is best for students if you create consensus definitions in the moment, using phrases and pictorial representations that the class develops together as they discuss their experiences in the lesson. When they co-create the meaning of the word, students 'own' the word—it honors their use of language and connects their specific experiences to the vocabulary of science beyond their classroom. It is especially important for emergent multilingual students to have a reference for this important vocabulary, which includes an accessible definition and visual support. Sometimes defining a word is a challenge. The Teacher Guide provides a suggested definition for each term to support you in helping your class develop a student-friendly definition that is also scientifically accurate" (Teacher Edition, page 18).

Some scaffolds are provided for students to access assessment tasks. However, these are typically in the form of the scaffolds provided to all students and no additional guidance is provided for students who may need additional support. Related evidence includes:

- Lesson 1: "Bear Diet, Bear Denning and Hibernation, and Bear Reproduction are written at similar reading levels. You may wish to allow students to self-select readings based on interest before dividing them into groups. Or, at your discretion, count students into random groups 1-8, or assign them into intentional, mixed-ability reading groups, with the students who need more reading support along with students who do not need the extra support. Bear Reproduction is the shortest. Bear Denning and Hibernation contains some statistics and percentages and could be a good fit for students who are drawn to math and numeracy. Many students will have some background knowledge relevant to all readings" (Teacher Edition, page 34).
- Lesson 2: Students are provided with a handout which provides support for making and supporting their claims.
- Lesson 4: A graphic organizer is provided which students use to construct their argument.
- Lesson 7: A handout is provided to guide peer feedback.

Students are provided with opportunities to share their thinking in multiple modalities. However, it is primarily limited to writing and speaking, and choice in modality is not provided. Related evidence includes:

- Lesson 1: “Investigate bear sightings in Wapusk. Display slide H and pass out Bear Sightings to each student. Explain that they have maps (slides I and J) that show where there have been recent reported sightings of the brown, black, and polar bears in both winter and summer. Ask them to turn and talk with a partner about how they think the bears might interact with the three habitats in Wapusk seasonally. After 3-4 minutes, display slide K and ask a few students to share their ideas” (Teacher Edition, page 27).
- Lesson 1: Students participate in a fishbowl discussion. “Facilitate a fishbowl discussion. Display slide CC. Set up two concentric circles of desks. One representative from each group will sit in the inner circle. One-two student volunteers should also join the inner circle representing Traditional Knowledge. Provide them with access to the quotes from Inuvialuit Quotes. The remainder of desks should create an outer circle where the majority of students will sit. Use the slide prompts to explain how a fishbowl discussion occurs. Refer to the Community Agreements and remind students that the purpose of this discussion is to move their science thinking forward. The goal is to answer the question: How are polar bear populations in different ecoregions affected by changes to Arctic sea[sic] ice? Students in the inner circle will share information from their ecoregion visual inquiry and discuss the questions on slide DD. Students in the outer circle will listen and complete part 2 of Comparing Polar Bear Populations. Students in the outer circle are responsible for deciding if the class has sufficiently answered the discussion questions. As the chosen representatives, only students in the fishbowl may contribute to the conversation” (Teacher Edition, page 37).
- Lesson 4: “Display slide W and distribute Bear Fossils Map to each student. Ask students to turn and talk about the data with an elbow partner using the prompt on the slide. Encourage them to compare the dates to Glacial and Interglacial Periods. After 5-7 minutes working in pairs, facilitate a class discussion of what students noticed” (Teacher Edition, page 97).
- Lesson 4: Students construct an argument in writing to answer the question “How did polar and brown bears become different species?” (B.5 Lesson 4 Slides, Slide P).
- Lesson 7: After viewing information about mass extinction events students are asked to write an initial argument individually with support from others in their small group.
- Lesson 8: “Share research findings. Display slide L. Direct students to sit with their groups from the last class and share what they figured out from their research. Refer to the community agreements and remind them it is important to hear from all group members to move their science thinking forward” (Teacher Edition, page 147).
- Lesson 8: “Allowing students to express their ideas using multiple modalities such as recording their responses on video or audio. This will be most useful for students who struggle with writing, but have strengths expressing themselves verbally to demonstrate their understanding in the task” (Teacher Edition, page 152).
- Lesson 9: “Organize materials in preparation for the Transfer Task. Display slide F. Ask students to take out their Progress Trackers and any other materials you think may help them as they complete the Transfer Task. Provide students with an opportunity to ask any clarifying questions that they may have. If questions came up at the end of the previous class, pause to answer them”. (Teacher Edition, page 158).

Multiple modalities are used on assessment tasks to convey information. However, these are typically used to convey different information rather than providing students support who are unable to access information in one of the other formats. Related evidence includes:

- Lesson 2: "For students for different abilities related to mobility, consider alternate movements such as wheelchair sprints or vigorous arm movements. Varying the activity type can support meaningful participation for students with different needs" (Teacher Edition, page 63).
- Lesson 4: "Universal Design for Learning: Throughout this lesson students engage in activities through multiple formats to provide additional representations. This can help support them as they process the evidence and piece together information from multiple domains and different time and spatial scales. Providing multiple formats for presenting the information provides more access for the diverse learners in your classroom" (Teacher Edition, pages 88–89).
- Lesson 9: On the bumblebee bee transfer task, information is shared using text, pictures, and graphs. While these different modalities are used to present the task, they all are used to convey different information and is not necessarily useful for students who may struggle accessing the material.

Suggestions for Improvement

- Consider providing specific guidance for allowing students to choose a modality for at least one of the formal assessment tasks (for example by allowing them to communicate their argument in a format other than writing).
- Consider diversifying the mode in which assessment tasks are communicated to students and through which students can demonstrate their proficiency.

III.E. COHERENT ASSESSMENT SYSTEM

Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.

Rating for Criterion III.E. Coherent Assessment System	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning because all assessment types are present throughout the material which connect to stated learning goals from all three dimensions. However, there is some mismatch between key learning claimed in the unit and elements claimed on key assessments.

An Assessment system overview is provided which clearly outlines the purpose and rationale of assessments across the materials. Related evidence includes:

- "Each OpenSciEd unit includes an assessment system that offers many opportunities for different types of assessments throughout the lessons, including pre-assessment, formative assessment, summative assessment, and student self-assessment. Formative assessments are embedded and called out directly in the lesson plans. Please look for the 'Assessment Icon' in the teacher support boxes to identify places for assessments. In addition, the table below outlines where each type of assessment can be found in the unit" (Teacher Edition, page 162).

- The assessment system overview contains a table which clearly outlines each assessment found in the materials, specifies the type of assessment given, and provides a rationale for the assessment. For example: "Formative This Electronic Exit Ticket addresses 3-D elements associated with the lesson-level performance expectations (LLPEs) for Lesson 3. The first Electronic Exit Ticket allows relatively quick individual assessment of students on a key LLPE. Teachers can quickly check students' understanding of how to integrate genetic information to infer evolutionary relationships for two species of bees. Additionally, students have an opportunity here to reflect on how understanding the situation with honey bees[sic] connects to their own lives, how they used science and engineering practices and crosscutting concepts in sensemaking, and the value of the classroom community agreements in supporting their learning" (Teacher Edition, page 162).

A pre-assessment is found in the materials. However, it is not completely aligned to elements claimed as a focus for the unit and does not allow for individual students to show current understanding. Related evidence includes:

- Lesson 1: Students individually develop initial models. "Develop initial models. Display slide JJ. Form groups of 3-4 and distribute a blank piece of chart paper and colored markers to each group. Have students draw a line through the center and give them 10 minutes to develop two models that explain what will happen to the populations of Arctic bears living in habitats with seasonally available vs. permanent ice as their environment changes. Suggest that groups list components, interactions, and mechanisms they want to include before they begin their models. Encourage the use of pictures, symbols, and/or words in their model to help represent and further explain their ideas. Prompt groups to consider factors related to climate change, habitat change, and interactions with other bears as they develop models. Encourage students to record any questions that emerge for them as they develop their models. They will build a Driving Question Board at the end of the lesson and productive questions will likely arise while modeling. Explain that they will be sharing these models with their peers, so they should make sure ideas are labeled and explained clearly" (Teacher Edition, page 40). Students then post their models around the room and participate in a gallery walk in which they note similarities and differences between models. Students then engage in discussion to create a classroom consensus model. The Assessment System Overview identifies that this can be uses as a pre-assessment of student learning: "The student work in Lesson 1 should be considered a pre-assessment. It is an opportunity to learn more about the ideas your students bring to this unit. Hearing these ideas early on can help you be more strategic in how to build from and leverage student ideas across the unit" (Teacher Edition, page 161). While elements of **Engaging in Argument from Evidence** are identified as the focal SEPs in the unit, they are not identified or used as part of the pre-assessment. In addition, it is unclear if these tasks can serve as a pre-assessment for any of the CCC elements that will be addressed in the unit. While this can serve as a pre-assessment of student knowledge, most components of the pre-assessment occur in small groups or whole class discussion and therefore cannot be used to ascertain individual student proficiency.

Formative Assessment opportunities are found throughout the materials. Related evidence includes.

- Lesson 2: Students are provided with a handout to make their claims and find supporting and refuting evidence.
- Lesson 4: "Develop an initial claim about the split. Say, We have some idea of what selection pressures the common ancestor bears might have experienced in different locations during the cycles of glaciation. Let's take some time to individually come up with a claim about what

caused brown and polar bears to split from their common ancestor during this time period. Display slide O and ask students to turn in a claim following the prompts on the slide. Refer to Key Developing an Argument for a sample claim" (Teacher Edition, page 91). Students then are provided with an opportunity to share their claims with another and look for similarities and differences. "Reread claims. Distribute the exit tickets students wrote at the end of the previous class. Display slide P and provide time for students to share and compare the claims they wrote" (Teacher Edition, page 92).

- Lesson 2: A handout is provided for the student thermoregulation investigation containing questions aligned to DCI and SEP elements. For example: "1. How did human body temperature change during exercise?", "4. How does the variation of the NOS3 gene that polar bear have affect how the polar bear behaved: a. on the treadmill? b. when interacting with brown bears around a whale carcass?", and "5. Make a claim supported by evidence to respond to the following: How and why will polar and brown bears interact in the Arctic as their environment changes? Consider evidence from scientific studies and your own investigations?" (B.5 Lesson 2 Handout, Thermoregulation Investigation, pages 1–2).
- Lesson 4: Students are asked to write an initial argument using a provided handout.
- Lesson 6: Students complete an Electronic Exit Ticket. The following questions are found on the Exit Ticket: "Describe a time in your own life when you experienced a change in environmental conditions where you saw a decline and how it impacted you", and "If polar bears go extinct because all the sea ice disappears, how do you predict that will affect the rest of the Arctic ecosystem?" (Lesson 6, Bears Exit Ticket).

Several opportunities for self-assessment are found throughout the materials. Related evidence includes:

- Lesson 3: Students complete an Exit Ticket. The following questions are found on the Exit Ticket which asks students to assess their own learning from each dimension: "How did obtaining and evaluating information from multiple sources during the lesson help you make sense of bear relatedness?", and "How did patterns of information at different scales help you make sense of bear relatedness?" (B.5 Lesson 3 Answer Key, L3 Electronic Exit, page 8). Students are also asked to respond to the following prompt with a yes/no answer: "I understand how today's class ties to the bigger picture for what we're studying in this unit" (B.5 Lesson 3 Answer Key, L3 Electronic Exit, page 8).
- Lesson 4: Students are provided with an opportunity to reflect on their initial arguments through the following prompts: "Consider how confident your feel in your argument right now and what additional information you need to support it.", and "Write down the additional evidence or data you need to complete your argument on Part 3 of Developing an Argument." (B.5 Lesson 4 Slides, Slide U).
- Lesson 4: "Students complete a self-assessment. Display slide GG and distribute Self-Assessment on Constructing an Argument to each student. Provide time for students to complete the self-assessment. Collect Self-Assessment on Constructing an Argument and make note of what students learned from the process and where they struggled. Bring these ideas to lesson 8, when students will be asked to construct and defend arguments again" (Teacher Edition, page 102).
- Lesson 6: Students complete an Electronic Exit Ticket. The following questions are found on the Exit Ticket: "How did using models during the lesson help you predict the evolution of the polar bear?", and "How did thinking about cause and effect help you explain the lesson question: What will happen to bear species in the Arctic in the future?" (Bears Exit Ticket).

- "Student self-assessment rubrics for giving and receiving feedback can be used throughout the unit. Opportunities include, after a discussion or at the end of a class period. The rubric helps students reflect on their participation in the class that day. Choose to use this at least once a week or once every other week. Initially, you might give students ideas for what they can try to improve for the next time, such as sentence starters for discussions. As they gain practice and proficiency with discussions, ask for their ideas about how the whole-class and small-group discussions can be more productive. Additional support can be found in the OpenSciEd Teacher Handbook: High School Science. In addition to this flexible resource, self-assessment has been written directly in the unit in Lessons 3, 6, 7" (Teacher Edition, page 164).
- "The Progress Trackers are thinking tools designed to help students keep track of important discoveries that the class makes while investigating phenomena and figure out how to prioritize and use those discoveries to develop a model to explain phenomena. It is important that what the students write in the Progress Trackers reflects their own thinking at that particular moment in time. In this way, the Progress Trackers can be used to formatively assess individual student progress or for students to assess their own understanding throughout the unit. Because the Progress Trackers are meant to be a thinking tool for kids, we strongly suggest it is not collected for a summative 'grade' other than for completion. In addition to this flexible resource, Progress Trackers have been written directly in the unit in Lessons 2, 3, 7" (Teacher Edition, page 164).

A summative assessment task is found in Lesson 9. However, the focus SEP on the assessment is not developed within the unit. Related evidence includes:

- Lesson 9: Students complete the Bumblebee Transfer Task which focuses on three focus elements claimed to be developed in the unit. While claimed DCI and CCC elements on this assessment are developed throughout the unit, the SEP element claimed (7.2 *Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments)* is not claimed in any lesson prior to this assessment opportunity and is not developed in lessons leading up to the assessment.
- While other focus elements of all three-dimensions are found in formative assessment opportunities throughout the unit, they are not assessed on the identified summative assessment in this lesson.

Suggestions for Improvement

- Consider capturing individual student performance on the labeled formative assessments. For example, have students write their initials on the post-it notes they add to the DQB.
- Consider revising the pre-assessment in Lesson 1 and transfer task in Lesson 9 so they more accurately reflect the key learning of the unit.
- Consider indicating that assessment opportunities in Lessons 4 and 7 serve as summative assessments for some specific elements which are not found on later assessments.

III.F. OPPORTUNITY TO LEARN

Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback.

Rating for Criterion III.F. Opportunity to Learn	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found Adequate evidence that the materials provide multiple opportunities for students to demonstrate performance of practices connected with their understanding of DCIs and CCCs because students have multiple opportunities to receive feedback and demonstrate growth in proficiency. However, these opportunities are primarily limited to SEP and DCI elements.

Throughout the materials, there are multiple opportunities for students to demonstrate their growth in proficiency in areas related to developing arguments and explaining how bear populations have changed over time. However, there are few opportunities for students to show growth in CCC elements. Throughout these opportunities students receive feedback from both the teacher and their peers. Related evidence includes:

- Lesson 1: Students individually develop initial models. "Develop initial models. Display slide JJ. Form groups of 3-4 and distribute a blank piece of chart paper and colored markers to each group. Have students draw a line through the center and give them 10 minutes to develop two models that explain what will happen to the populations of Arctic bears living in habitats with seasonally available vs. permanent ice as their environment changes. Suggest that groups list components, interactions, and mechanisms they want to include before they begin their models. Encourage the use of pictures, symbols, and/or words in their model to help represent and further explain their ideas. Prompt groups to consider factors related to climate change, habitat change, and interactions with other bears as they develop models. Encourage students to record any questions that emerge for them as they develop their models. They will build a Driving Question Board at the end of the lesson and productive questions will likely arise while modeling. Explain that they will be sharing these models with their peers, so they should make sure ideas are labeled and explained clearly" (Teacher Edition, page 40). While this provides an opportunity for students to show understanding in claimed DCI learning, targeted SEP and CCC elements in the unit are not incorporated into this opportunity.
- Lesson 2: The class uses information on the Bear Cards to provide evidence for a claim. In a class discussion, they listen to the thinking of others and revise their claim.
- Lesson 4: "Develop an initial claim about the split. Say, We have some idea of what selection pressures the common ancestor bears might have experienced in different locations during the cycles of glaciation. Let's take some time to individually come up with a claim about what caused brown and polar bears to split from their common ancestor during this time period. Display slide O and ask students to turn in a claim following the prompts on the slide. Refer to Key Developing an Argument for a sample claim" (Teacher Edition, page 91). Students then are provided with an opportunity to share their claims with another and look for similarities and differences. "Reread claims. Distribute the exit tickets students wrote at the end of the previous class. Display slide P and provide time for students to share and compare the claims they wrote" (Teacher Edition, page 92). Students then construct an argument which is turned into the teacher in order for feedback to be provided.
- Lesson 6: Students complete an Electronic Exit Ticket. The following questions are found on the Exit Ticket: "Describe a time in your own life when you experienced a change in environmental conditions where you saw a decline and how it impacted you", and "If polar bears go extinct because all the sea ice disappears, how do you predict that will affect the rest of the Arctic ecosystem?" (Lesson 6, Bears Exit Ticket).

- Lesson 7: Students write an argument with their group. "Write an argument using a pattern of evidence that explains the main cause of mass extinctions on earth on Part C of the Extinctions Graphic Organizer" (B.5 Lesson 7 Slides, Slide N). A strategy for providing feedback is given. "What to do: Remind students of the self-assessment they did on Self-Assessment on Constructing an Argument and to reread how they wanted to improve their arguments. Prompt students to review Bear Interaction Claims and Bear DNA Tree to remember how to write arguments supported with evidence and reasoning. Use Key Extinctions Graphic Organizer to support groups as they develop arguments. Collect Extinctions Graphic Organizer at the end of class from students who struggle with writing arguments to provide additional assistance" (Teacher Edition, page 132). Students also receive feedback from peers. "Facilitate a peer review of initial arguments. Distribute Peer Feedback Rubric to each student. Pair students up with another student who was not in their group when they visited the mass extinction stations to share their initial argument and complete Peer Feedback Rubric. Provide time for students to read one another's arguments, write feedback and discuss the feedback with one another" (Teacher Edition, page 133). Students have a chance to revise their thinking after this feedback and class discussions. "Revise initial arguments. Say, I think we now have a better understanding of what caused mass extinctions in the past and the consequences for biodiversity. Let's spend some time revising our arguments. Display slide W and provide time for students to revise arguments based on the prompt. Point out the subtle change in the argument writing prompt and that they should make sure they are explaining how extinctions affect biodiversity and supporting this idea with additional evidence if necessary" (Teacher Edition, page 135).
- Lesson 8: At the end of the lesson, students individually complete an Exit Ticket using the following prompt: "Complete the Extinction Prevention Argument explaining: Do you think people should make an effort to protect the polar bear from extinction? Choose at least 2 of the solutions from the extinction prevention case studies that you think would be most useful in preventing the extinction of the polar bear. ● Defend an argument for why we should or should not implement those solutions based on the science, constraints and/or ethical considerations" (B.5 Lesson 8 Slides, Slide U).

Suggestions for Improvement

Consider providing prompts which explicitly ask for students to show thinking related to CCC elements and receive feedback on their performance from the teacher and peers.

OVERALL CATEGORY III SCORE: 3 (0, 1, 2, 3)	
Unit Scoring Guide – Category III	
Criteria A-F	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least one criterion
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

SCORING GUIDES FOR EACH CATEGORY

UNIT SCORING GUIDE – CATEGORY I (CRITERIA A-F)

UNIT SCORING GUIDE – CATEGORY II (CRITERIA A-G)

UNIT SCORING GUIDE – CATEGORY III (CRITERIA A-F)

OVERALL SCORING GUIDE

Scoring Guides for Each Category

Unit Scoring Guide – Category I (Criteria A-F)	
3	At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C
2	At least some evidence for all unit criteria in Category I (A–F); adequate evidence for criteria A–C
1	Adequate evidence for some criteria in Category I, but inadequate/no evidence for at least one criterion A–C
0	Inadequate (or no) evidence to meet any criteria in Category I (A–F)

Unit Scoring Guide – Category II (Criteria A-G)	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least two criteria
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

Unit Scoring Guide – Category III (Criteria A-F)	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least one criterion
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

OVERALL SCORING GUIDE	
E	**Example of high quality NGSS design—**High quality design for the NGSS across all three categories of the rubric; a lesson or unit with this rating will still need adjustments for a specific classroom, but the support is there to make this possible; exemplifies most criteria across Categories I, II, & III of the rubric. (total score ~8–9)
E/I	**Example of high quality NGSS design if Improved—**Adequate design for the NGSS, but would benefit from some improvement in one or more categories; most criteria have at least adequate evidence (total score ~6–7)
R	**Revision needed—**Partially designed for the NGSS, but needs significant revision in one or more categories (total ~3–5)
N	**Not ready to review**—Not designed for the NGSS; does not meet criteria (total 0–2)